

FINAL
HEALTH AND SAFETY PLAN
FOR
REMEDIAL INVESTIGATION
KOPPERS/SOUTH CAVALCADE SITE
HOUSTON, TEXAS
May 1985

Koppers Company, Inc.
Pittsburgh, Pennsylvania 15219

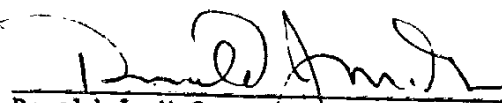
KOPPERS

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Approved by


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Date

9/5/85

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1.0 INTRODUCTION

1.1 Background

This Health and Safety Plan is intended to provide guidance for: (1) personnel working on site in the remedial investigation at the former Kopper's Company, Inc. South Cavalcade Wood Treating Facility in Houston, Texas and (2) other personnel/general population in proximity to site investigative activities. The plan has been developed to minimize the risk of injury or illness resulting from activities undertaken at the site during the remedial investigation.

A remedial investigation of the former South Cavalcade site is being conducted to characterize the nature and extent of contamination of soils, ground water, and surface water and its threat to human health and environment. The remedial investigation consists of the following general activities:

1. Monitoring well installation
2. Falling head permeability testing
3. Groundwater sampling (shallow and deep)
4. Surficial soil sampling
5. Subsurface soil sampling
6. Surface water sampling
7. Sediment sampling
8. Air Monitoring
9. Geophysical Investigations
10. Nonsoil Materials Investigation

The information collected during the remedial investigation will be used in a feasibility study to identify, evaluate and select the most cost effective alternative.

1.2 Site Description and History

The South Cavalcade site is currently bounded by the Houston Belt Terminal Railroad tracks to the east, Cavalcade Road to the north, Missouri Pacific railroad tracks to the west, and Collingsworth Road

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to the south (see Figure 1-1). The site currently consists of approximately 55 acres on a parcel of land 1 1/2 miles south west of the intersection between Loop 610 and U.S. Route 59 (Eastex Freeway).

The majority of the site area was formerly used as a production facility for wood preserving and wood treatment operations, including the use of creosote and metal-salt treatment with chromated zinc chloride (20% zinc, 80% hexavalent chromium) and chromated copper arsenic (CCA) solutions. Data on the composition of creosote, creosote-coal tar solutions, and CCA is included in Tables 1-1, 1-2, and 1-3, respectively.

From 1911 to 1939 the plant was operated by the National Lumber and Creosoting Company. This operation consisted of a production facility on the south central corner of the site and "dripping" and drying areas toward the center and northern areas of the site. Koppers Company purchased the operation in 1940 and constructed a coal tar distillation facility in the eastern section of the site, while maintaining the wood treating operations in the same locations as those used by National Lumber and Creosoting Company. The feed to the distillation facility was coal tar from off-site coal carbonization (coke) plants. A typical composition of coal tar is given in Table 1-4. Products from the distillation of coal tar include creosote and other wood preserving oils (distillates), road tars, industrial pitches, and pitch coke (residuals).

In 1962, Koppers closed the operation, removed all plant buildings and covered the site with soil. Currently, three palletized trucking firms and a leasing company are located within the site boundary. Site plans derived from aerial photographs for 1953, 1984, and an overlay of the 1953 site plan on the 1984 site plan are shown in Figures 1-2, 1-3 and 1-4.

In the early 1980's the Harris County Metropolitan Transit Authority (MTA) became interested in the site for use as a combined railyard, shop and station for a proposed light rail system. A routine geotechnical investigation revealed several localized areas to be contaminated with creosote waste products. A subsequent

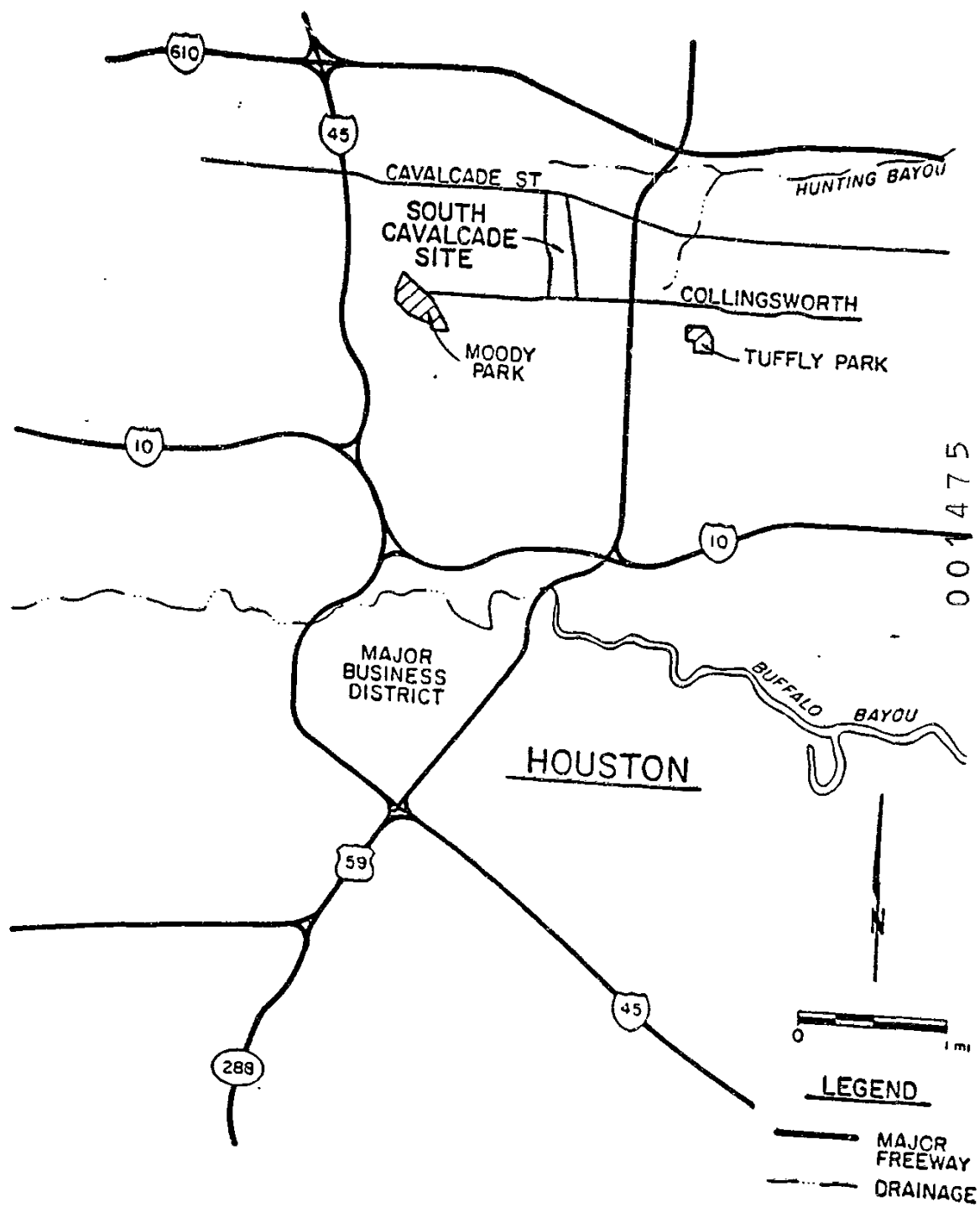
























Figure 1-1
Site Location Map

TABLE 1-1
REPORTED ANALYSES FOR SPECIFIC COMPONENTS IN CRUISE OIL (wt. per.)

Component	Formula	Structure	Boiling Point, °C (a)	Hestler 1974 (b)	Lorenz and Gjoval, 1972 (c)	Lijinsky (d) et al 1963 (e)	Lijinsky (f) et al 1957 (g)	Stace 1954 (h)
Naphthalene	C ₁₀ H ₈		218	-	-	-	-	-
2-Methylnaphthalene	C ₁₁ H ₁₀		241	-	3.0	-	-	-
1-Methylnaphthalene	C ₁₁ H ₁₀		245	-	1.2	-	-	8.6 ± 2.0
Biphenyl	C ₁₂ H ₁₀		255	-	0.9	-	-	2.5 ± 1.2
Acenaphthene	C ₁₂ H ₁₀		279	-	0.8	-	-	-
Dimethylnaphthalenes	C ₁₂ H ₁₂	-	262-269 (a)	12.6 ± 0.4 / 15.0 ± 1.1	9.0	-	-	-
Dibenzofuran	C ₁₂ H ₈ O		287	-	2.0	-	-	3.1 ± 0.8
Carbazole	C ₁₂ H ₉ N		355	(h)	5.0	-	-	-
Fluorene	C ₁₃ H ₁₀		297 (g)	-	2.0	0.220/0.142	0.267	0.9 ± 0.2
Methylfluorenes	C ₁₄ H ₁₂	-	318	-	10.0	-	-	2.4 ± 0.4
Phenanthrene	C ₁₄ H ₁₀		340	-	3.0	-	-	3.0 ± 0.5
Anthracene	C ₁₄ H ₁₀		340	-	21.0	5.99/3.33	-	-
9,10-Dihydroanthracene	C ₁₄ H ₁₂		312 (g)	-	2.0	1.21/1.20	4.65	10.8 ± 2.0
Methylphenanthrenes	C ₁₅ H ₁₂	-	354-355	-	-	-	0.60	1.6 ± 0.2
Methylantracenes	C ₁₅ H ₁₂	-	360	-	3.0	-	-	0.2 ± 0.1
Fluoranthene	C ₁₆ H ₁₀		382	4.0 ± 0.1/6.0 ± 0.2	4.0	-	-	-
Pyrene	C ₁₆ H ₁₀		393	3.0 ± 0.2/5.5 ± 0.1	10.0	2.48/2.22	-	-
Benzo(a)fluoranthene	C ₁₇ H ₁₂		413	-	8.5	0.91/0.68	0.76	3.5 ± 1.1
Chrysene	C ₁₈ H ₁₂		448	1.9 ± 0.5/3.1 ± 0.2	2.0	-	0.41	2.2 ± 0.5
Benzo(b)anthracene	C ₁₈ H ₁₂		458 (g)	-	3.0	0.134/0.094	-	-
Benzo(j)fluoranthene	C ₂₀ H ₁₂		480 (g)	-	-	0.277/0.294	0.123	-
Benzo(k)fluoranthene	C ₂₀ H ₁₂		490 (g)	-	-	0.029/0.029	0.267	-
Benzo(a)pyrene	C ₂₀ H ₁₂		496 (g)	-	-	0.030/0.011	-	-
Benzo(e)pyrene	C ₂₀ H ₁₂		493 (g)	-	-	0.014/0.022	-	-
Perylene	C ₂₀ H ₁₂		460 (g)	-	-	-	0.01	-
Benzo(b)chrysene	C ₂₂ H ₁₄		500 (g)	-	-	0.018/0.015	-	-
						0.004/0.004	0.004 ± 0.004	-
						0.003/0.006	-	-
Totals:				20.5/32.9	90.4	9.3/8.0	7.5	46.5 ± 7.1

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Notes:

- (a) From (Lorenz & Gjovik, 1972) unless otherwise indicated.
- (b) Results are for a Class I low residue creosote for pressure treatment of poles (left of slash) and a Class III medium residue creosote for treatment of piles, lumber, structural timbers used in coastal waters (right of slash) (Nestler, 1974, p.50) where classes are per U.S. Federal Supply Service Creosote Coal Tar Technical Federal Specification TT-C-6456. Nov. 14, 1967 (ibid. p.46). Results are mean \pm standard deviation for 3 analyses for the Class I creosote (except chrysene with two) and 4 analyses for the Class III creosote. Analyses made by gas chromatography with thermal conductivity detection using normal alkanes as internal standards and polar planimeter or cut-weigh methods for measuring peak areas.
- (c) Values shown are "approx. pct. \pm 0.7%" (Lorenz & Gjovik, 1972, p. 34). Analysis was by gas chromatography with flame ionization detection using a reference mixture of compounds "as a quantitative and qualitative standard for calibrating the gas chromatograph" (ibid, p.32). The origin of the creosote sample used was not described, but the results of its analysis by AWPA standard A1 are given.
- (d) Results are for "analysis of two different aliquots of the same material" (Lijinsky, et al, 1963, p. 954), which was described as a creosote which was "obtained commercially" (ibid p. 953). Analysis was by liquid/liquid extraction (cyclohexane/methanol to remove phenolics and then cyclohexane nitromethane) followed by paper chromatography with identification and quantification by fluorescence emission and absorption spectra, respectively.
- (e) Creosote sample described as "a #1 oil, dry point 240°C, collected as a distillation fraction from a Wilton still" (Lijinsky, et al, 1957, p. 68). Analysis was by "a combination of chromatography and ultraviolet spectrophotometry" (ibid, p.689) with identification "by means of the absorption spectra, melting points, and preparation of the 2,4,7 - trinitrofluorenone complexes of (the) compounds" (ibid p. 689). Results originally reported in gm/l but are given in Table 3-12 as wt. pct. based on a reported density of 1030 gm/l (ibid, p. 689).
- (f) Data reported are mean \pm standard deviation for eight different domestic creosote oils covering a range of residue, tar acids, and naphthalene contents (see Stasse's Table 1 for description and inspections of creosote oils). Analysis "by the use of fractionation (distillation) data, melting points of fractions, ultraviolet absorption data; and chemical analysis" (Stasse, 1954, p. 36).
- (g) From (Anderson & Wu, 1963, p. 744-747).
- (h) Acenaphthene and dibenzofuran reported as sum of both compounds.
- (i) Total shown is mean \pm standard deviation for the eight totals of Stasse's analyses and does not agree with total of components listed (46.4%) due to rounding errors.

TABLE 1-2
COMPOSITIONS OF CREOSOTE/COAL TAR SOLUTIONS
FROM THREE WOOD-TREATING PLANTS(a)

	Plant A 60/40 Creosote Coal Tar Soln.	Plant B 60/40 Creosote Coal Tar Soln.	Plant C 80/20 Creosote Coal Tar Soln.
Low Boilers	1.1%	0.6%	3.7%
Naphthalene	10.7	12.9	20.2
Methylnaphthalenes	3.2	4.8	3.9
Biphenyl	0.62	1.5	1.2
Unknown	-	0.6	1.3
Acenaphthene	4.2	4.6	3.2
Dibenzofuran	2.4	2.8	2.0
Fluorene	3.6	3.9	3.1
Unknown	-	1.4	1.0
Phenanthrene/ anthracene	12.8	11.7	9.7
Carbazole	2.8	1.1	0.8
Methylphenanthrenes	1.6	2.4	2.7
Fluoranthene	5.4	5.8	5.0
Pyrene	4.0	5.2	4.4
Chrysene	1.2	2.3	2.2
Unknowns	8.4	1.7	2.2
Total	62.0%	63.3%	66.6%
Unknowns	1.1%		
Benzo(k)fluoranthene	1.4		
Perylene	1.0		
o-Phenylenepyrene	0.2		
1, 12-Benzoperylene	0.4		
Total	66.1%		

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(a) Reproduced from (AWPI, 1979; Volume III, Position Document #1, Table 4.
No details given on sample origins or analytical methods.

TABLE 1-3


























CHEMICAL COMPOSITION OF CHROMATED COPPER ARSENIC (CCA)

	Percent by Weight		
	<u>Type A</u> ⁽¹⁾	<u>Type B</u> ⁽²⁾	<u>Type C</u> ⁽³⁾
CrO ₃	65.5	35.3	47.5
CaO	18.1	19.6	18.5
As ₂ O ₅	16.4	45.1	38.0

- (1) Type A is normally supplied to the treating plant as a solution with 60% concentration on an oxide basis, with a pH between 1.6 and 3.2.
- (2) Type B is supplied to the treating plant in paste form and diluted to the concentration required.
- (3) Type C is supplied to the treating plant as 50% solution concentrate. This formulation was first introduced in 1968, therefore this does not apply to CCA used at the South Cavalcade site.

TABLE 1-4

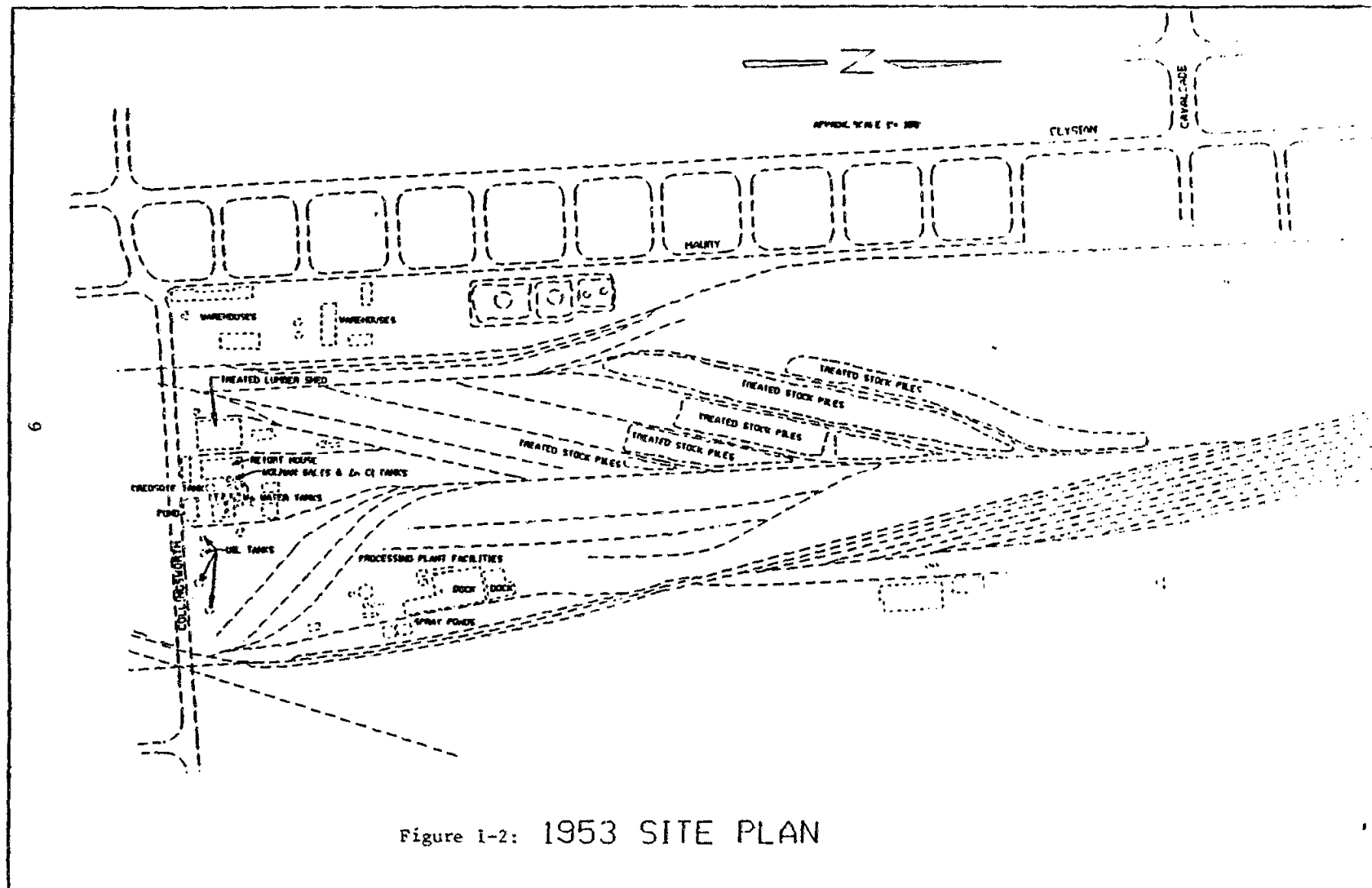
REPORTED ANALYSES FOR SPECIFIC COMPONENTS IN COAL TAR

Animal Carcinogenicity (f)	Component	Formula	Structure	Boiling Point, °C (a)	Guerin, et al 1978 (5)	Lijinsky, 1963 (c)	Boonag, 1961 (d)	Fisher 1958 (e)
+	Benzene	C ₆ H ₆		80	-	-	-	-
-	Toluene	C ₇ H ₈		111	-	-	-	0.1
-	Xylenes	C ₈ H ₁₀		138-144	-	-	-	0.2
-	Phenol	C ₆ H ₅ OH		181	-	-	-	1.0
-	Cresols	C ₇ H ₇ OH		191-202	-	-	-	0.7
-	Xylenols	C ₈ H ₉ OH		201-227	-	-	-	1.1
-	Pyridine	C ₅ H ₅ N		115	-	-	-	0.2
-	Naphthalene	C ₁₀ H ₈		210	-	-	-	0.1
-	Methylnaphthalenes	C ₁₁ H ₁₀	-	241-245	-	-	-	10.9
-	Dimethylnaphthalenes	C ₁₂ H ₁₂	-	262-269	-	-	-	2.5
-	Acenaphthene	C ₁₂ H ₁₀		277	-	-	-	3.4
-	Carbazole	C ₁₂ H ₉ N		355	-	-	-	1.4
-	Fluorene	C ₁₃ H ₁₀		297	-	0.152/0.127	-	1.1
-	Anthracene	C ₁₄ H ₁₀		340	-	-	-	1.6
-	Phenanthrene	C ₁₄ H ₁₀		340	-	0.288/0.435	-	1.1
-	Fluoranthene	C ₁₆ H ₁₀		393	-	1.36 / 1.75	-	4.0
-	Pyrene	C ₁₆ H ₁₀		394	-	1.77 / 1.78	-	-
+	Chrysene	C ₁₈ H ₁₂		436	-	0.795/1.05	-	-
+	Benz(a)anthracene	C ₁₈ H ₁₂		438	-	0.213/0.286	-	-
+	Benzo(j)fluoranthene	C ₂₀ H ₁₂		~480	-	0.624/0.698	-	-
-	Benzo(k)fluoranthene	C ₂₀ H ₁₂		480	-	0.063/0.045	-	-
+	Benzo(a)pyrene	C ₂₀ H ₁₂		496	0.38±0.17	0.109/0.107	-	-
-	Benzo(c)pyrene	C ₂₀ H ₁₂		493	-	0.208/0.176	3.0	-
-	Perylene	C ₂₀ H ₁₂		460	-	0.185/0.188	-	-
+	Benzo(g,h,i)perylene	C ₂₂ H ₁₂		500	-	0.070/0.076	-	-
-	Benzo(b)chrysene	C ₂₂ H ₁₄		~500	-	0.123/0.189	-	-
+	Dibenz(a,h)anthracene	C ₂₂ H ₁₄		-	-	0.093/0.080	-	-
				Totals		6.1/7.0	-	29.4

Notes:

- (a) From (Anderson & Wu, 1963).
- (b) No details given on analytical techniques or sample origin.
- (c) Results are for "analysis of two different aliquots of the same material" (Lijinsky, et al, 1963, p-166).
The sample was a "medicinal coal tar...obtained from Cazzolo Drug and Chemical Co., Chicago" (ibid, p. 953).
- (d) No information given on sample origin.
- (e) From Table 3.2-3.
- (f) From Chapter 6, particularly Table 6-1.

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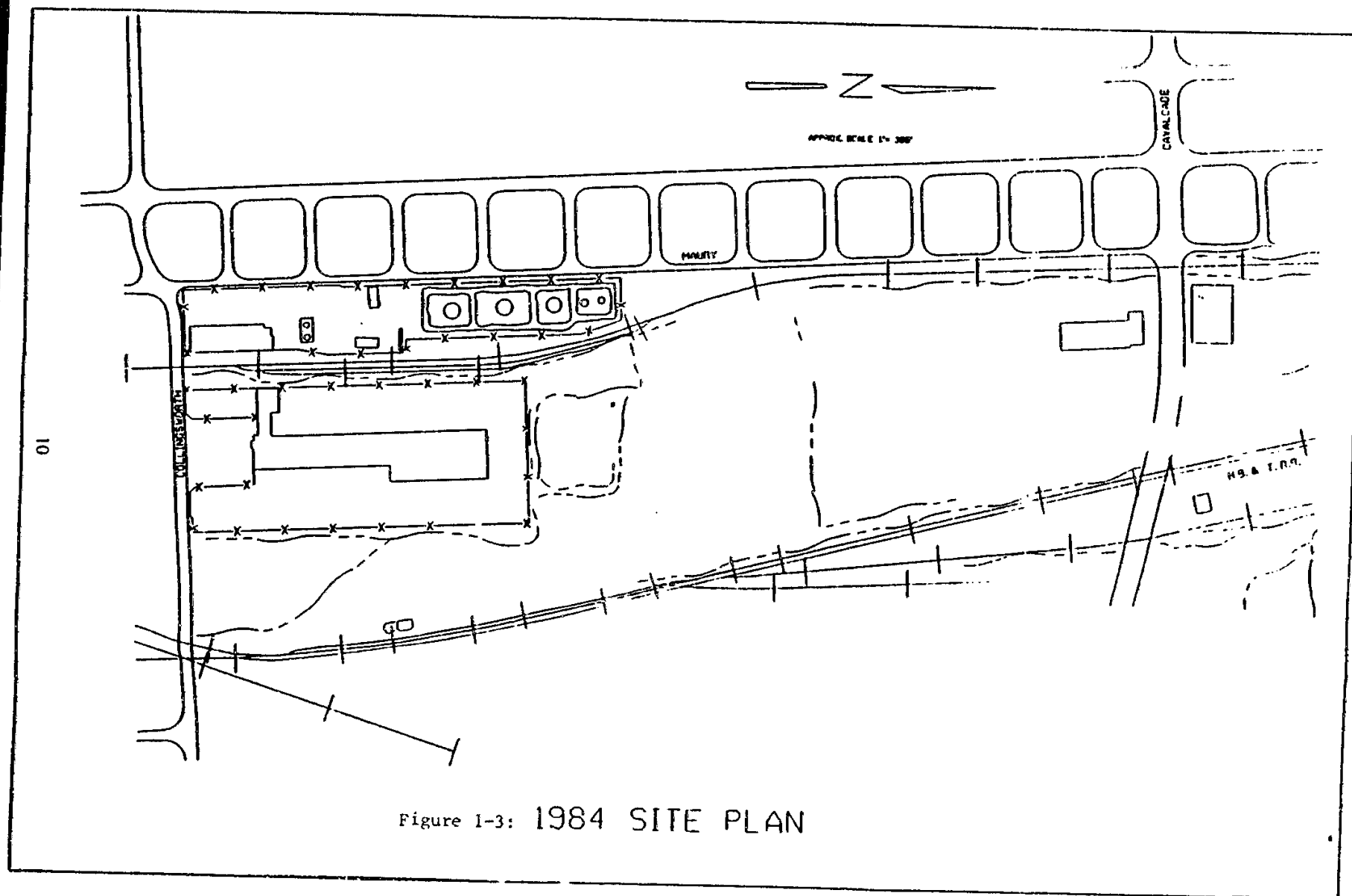
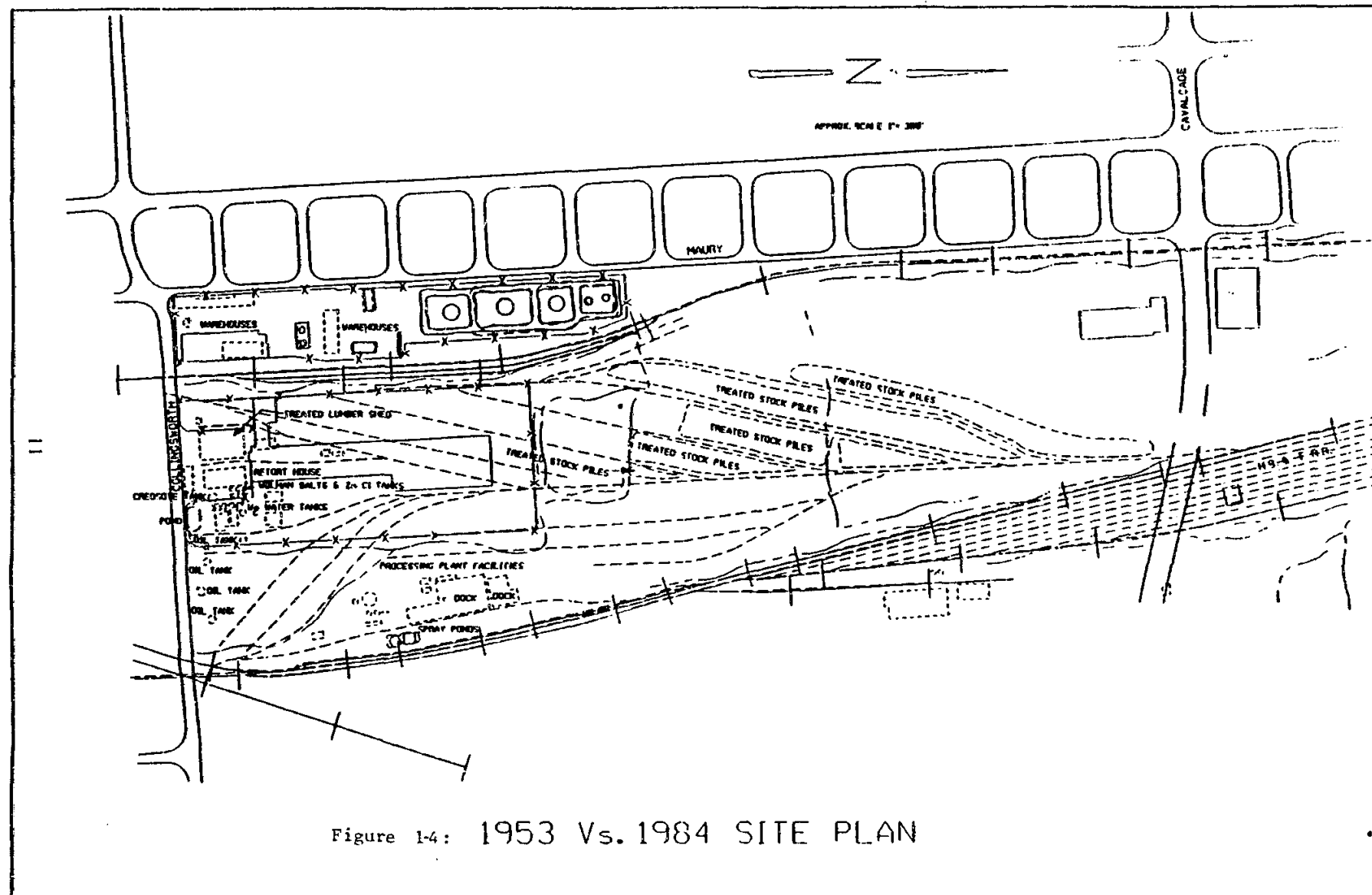


Figure 1-3: 1984 SITE PLAN

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contaminant survey performed for the Houston MTA by Camp Dresser and McKee, Inc. (CDM) in 1983 indicated the presence of soil and shallow groundwater contaminants including polynuclear aromatic hydrocarbons (PAH) and heavy metals. In 1983, the site was handed over to the US EPA and placed on the National Priority List (NPL) with a hazard ranking of 38.7.

The CDM investigation included 4 sediment samples, 2 surface water samples, 4 surface soil samples, 10 soil borings, 13 subsurface soil samples, the installation of 9 shallow and 1 deep observation well, and 3 production well samples. The soil sampling analysis disclosed a high degree of contamination with both organic (PAH) and inorganic (heavy metals) compounds in the vicinity of suspect areas, particularly near the soil surface. The level of contamination decreases rapidly with depth. The groundwater sampling conducted by CDM indicated that the shallow water table conditions at the site and the shallow sand strata are locally contaminated with both PAH and toxic metal compounds, consistent with the surface soil contamination found near the previous disposal areas. Surface water and deep groundwater sampling indicated no significant threat to the public health or the environment. A summary of previous investigations of this site is included in Appendix I (Interim Site Characterization Report).

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2.0 RESPONSIBILITY

A designated Koppers Company Inc. on-site person will be the Health and Safety Officer (HSO). This person will be certified in first aid by the American Red Cross and will be responsible for all health and safety activities, including subcontractor activities, air monitoring, overseeing the decontamination of equipment and materials leaving the contaminated area, providing and enforcing the use of personnel protective equipment, and training of personnel as described in section 3.0.

This person will have had extensive experience in field operations with air monitoring equipment, personnel protective equipment, decontamination procedures, and emergency response procedures. In addition, this person will have had the following training:

- o First Aid (Red Cross Training) - 8 hours
- o Cardiopulmonary Resuscitation (Red Cross Training) - 8 hours
- o Respiratory Protection - 8 hours
- o Protective Clothing - 4 hours
- o Use of Safety Equipment - 4 hours
- o Decontamination Procedures - 4 hours

The HSO will also work with the Health and Safety person designated by the subcontractor in the design and implementation of the contractor's program. The HSO will be onsite with the investigative team at all times.

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3.0 TRAINING

The Health and Safety Officer will conduct a training program designed to ensure that field personnel are aware of the hazards at the site and that they perform their work in a manner that will minimize to the greatest extent possible, risk to personal health and safety. The health and safety training will include the following:

- o A general overview of the project and site,
- o An explanation of exposure routes and potential effects of contaminants identified at the site, with the focus on creosote and coal tar waste materials,
- o Requirements for personnel protection, respirator training, skin protection, etc.
- o The "Buddy System",
- o Decontamination and/or disposal procedures for clothing and equipment,
- o Personal hygiene requirements,
- o Action to be taken in the event of an unacceptable level of airborne contaminants,
- o Appropriate response to site emergencies, including personal injuries and accidents
- o Prohibited actions or procedures (e.g., eating, smoking, contact lenses), and
- o Responsibility of field team supervisor relative to health and safety.

The site specific training program will involve at least 2 hours of instruction per employee. In addition, job specific instructions will be reviewed before beginning each new phase of work.

Records of site personnel having completed this training will be maintained by the Health and Safety Officer and will be retained by Koppers in central project files.

On a weekly basis, and before each major change in operations, the HSO will conduct follow-up training as related to actual site operations. The topics of this training will be selected according to the needs and requirements of actual job situations.

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4.0 MEDICAL SURVEILLANCE PROGRAM

4.1 Purpose

The purpose of the worker medical surveillance program is to insure to the extent possible that all persons participating in field activities at the South Cavalcade site are in good health and fit to perform field activities, and to verify that such work has not resulted in employee ill health.

4.2 Procedures

All personnel, including subcontractors, subject to occupational exposure at the site will be required to have had a medical examination within the past year prior to beginning field operations at the South Cavalcade site. Protocols will be approved by the Health and Safety Officer. The medical examination will consist of the following:

- o Review and documentation of medical history
- o General physical
- o Pulmonary Function Test (FVC and FEV)
- o SMA 24 blood chemistry
- o Complete Blood Count (CBC)
- o Chest X-Ray (if medically indicated)
- o Heavy Metals Screen (urine analysis), only if medically indicated

Medical surveillance will include a judgement by the examining physician of the ability of the employee to use negative and positive pressure respirators. Prospective site staff determined to have medical conditions which could directly or indirectly be aggravated by exposure to those chemical substances within the site environment or the use of respiratory equipment will not be employed on this project.

The HSO in consultation with Kopper's Corporate Medical Director or his designee will decide whether an employee is to undergo re-examination should an employee develop an illness or injury during the site activities. The physician must certify that the employee is fit to return to work before participating in site activities. In addition, the Health and Safety Officer can request additional medical testing if abnormal site exposure occurs. An exit examination of employees exposed to hazardous site conditions throughout the length of the project will be scheduled upon completion of the project.

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5.0 DECONTAMINATION

5.1 Purpose

Decontamination procedures will be implemented for equipment and personnel to ensure that suspected contaminants are adequately controlled and to avoid the transfer of contaminants to vehicles, administrative areas, and other personnel.

5.2 Equipment Procedure

Whenever possible, equipment will be decontaminated before it leaves the site. Wash water will be collected and stored in drums, in a secure location, and disposed of in accordance with applicable regulations. Verification that equipment leaving the site has been adequately decontaminated is the responsibility of the Health and Safety Officer. Equipment that cannot be adequately decontaminated at the site will be double bagged and transported to another area for eventual decontamination or disposal in accordance with all applicable regulations. The standard operating procedure (SOP) for decontamination of field equipment is included as Appendix I.

5.3 Personnel and Protective Equipment Decontamination

On site personnel will be required to thoroughly wash hands and face and remove contaminated clothing prior to smoking, handling food or drinks, or leaving the site. On a daily basis personnel shall scrub boots, hard hats, and gloves in a 5% solution of trisodium phosphate (TSP), rinse with clean water and allow to dry overnight. The inside surface of each must also be inspected for contamination. Any contamination must be removed, the item cleaned or washed as above, or discarded. Respirators will be cleaned daily with a commercially available cleaner-sanitizer, if worn. Any personnel protective equipment to be thrown away will be placed in drums and disposed of in accordance with all applicable regulations. The following procedures will be followed for personnel decontamination:

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Gross Decon Area (total area covered with plastic drop cloth):

- o segregated equipment drop for tools and/or any other equipment that will be reused on/in the area. This will be a plastic drop cloth.
- o 20 gal. wash tub containing wash solution of sodium carbonate and/or trisodium phosphate and 2 long handle scrub brushes.
- o 20 gal. wash tub containing clean water for rinsing.
- o plastic lined drum for disposal of tyveks, any contaminated garments, and non reusable or damaged protective clothing.

Personnel will now enter decon-area and complete decon procedures:

- o Storage Areas for storing boots, hard hat, and non-contaminated clothing.
- o Shower Facilities - if deemed necessary by the HSO according to daily activities.
- o Redress Area - put on clean clothes and exit decon area into clean zone.

During periods of exiting from the contaminated zone for breaks, restroom or lunch, personnel will follow these amendments:

- o If there is heavy contamination, the employee will proceed through total decontamination before exiting.
- o If there is not heavy contamination, the Contractor employees will go through decontamination down to removal of work clothes. The employee will then wash his face, neck, hands and arms before moving to the break area.

During periods of minor emergencies that exiting of the contaminated zone would be necessary, personnel will follow these amendments:

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- 1) The worker will go through gross decontamination, drop outer garments in the area and receive first aid at that time.
- 2) If the accident is not serious, the worker, after being treated, will return to the contaminated area after redressing.
- 3) If the accident is serious, the worker will be immediately transported to the hospital.

If more elaborate personnel protection equipment is required (e.g., Level C), decontamination procedures will be modified to be consistent with the increased level of protection (e.g., see Appendix V).

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6.0 PROCEDURES

6.1 General

The following general policies/procedures will be in effect at the South Cavalcade site:

- o The Health and Safety Officer will be notified before anyone enters the site area,
- o The buddy system will be in effect at all times,
- o Personnel must wash hands and face before smoking, drinking, eating, using toilet facilities, or leaving the site,
- o All personnel equipment will be decontaminated or properly disposed of before leaving the site,
- o Changing of clothes and personnel protective equipment will take place only in a designated change area,
- o Contact lenses will not be worn on site,
- o Sanitary facilities will be provided,
- o Personnel violating safety procedures will be removed from the job,
- o All activities will comply with applicable federal and state laws, and
- o Work zones will be honored.

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6.2 Hazard Analysis

A preliminary hazard analysis has been conducted to ensure that site activities, personnel protection, and emergency response are consistent with the specific contaminants expected to be encountered. The hazard analysis forms the foundation for the Health and Safety Plan.

The contaminants of concern at the site include methylene chloride, ethylbenzene, arsenic⁽²⁾⁽³⁾, chromium⁽²⁾, and coal tar products⁽²⁾⁽⁴⁾ which contain various volatile to practically non-volatile polynuclear aromatic hydrocarbons (PAH) including acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene⁽¹⁾, benzo(a)pyrene⁽¹⁾, 3,4, benzo fluoranthene⁽¹⁾, chrysene⁽¹⁾, fluoranthene, fluorene, naphthalene, phenanthrene, and pyrene. The available and applicable OSHA permissible exposure limits (PEL) from 29 CFR 1910.1000, threshold limit values - time weighted average (TLV-TWA) and threshold limit values - short term exposure limit (TLV-STEL) from the American Conference of Governmental Industrial Hygienists (ACGIH) are listed below.

	TLV-TWA	TLV-STEL	PEL
o Methylene Chloride	100 ppm (350 mg/m ³)	500 ppm (1740 mg/m ³)	500 ppm (1740 mg/m ³)
o Ethyl Benzene	100 ppm (435 mg/m ³)	125 ppm (545 mg/m ³)	100 ppm (435 mg/m ³)
o Arsenic	0.2 mg/m ³	N/A	0.010 mg/m ³
o Chromium (VI)	0.05 mg/m ³	N/A	0.1 mg/m ³
o Zinc Chloride fume	1 mg/m ³	2 mg/m ³	1 mg/m ³
o Naphthalene	10 ppm (50 mg/m ³)	15 ppm (75 mg/m ³)	10 ppm
o Coal Tar Pitch	0.2 mg/m ³	N/A	0.2 mg/m ³
Volatiles ⁽⁴⁾			

(1) Suspected Carcinogen

(2) These substances are recognized as human carcinogens. There is sufficient evidence for the carcinogenicity of chromium and certain chromium compounds both in humans and experimental animals (IARC, and NTP 82-330). Certain water insoluble compounds (ACGIH TLVs 1984-85). Specific compounds not identified.

(3) Refer to 29 CFR 1910. 1018 "Inorganic Arsenic."

(4) Not specifically titled "Coal Tar Pitch Volatiles" in IARC or by NTP 82-330. However, creosote and coal tar fumes are mentioned by IARC and quoted by NTP 82-330 under the subject title "Soots, Tars and Mineral Oils." ACGIH assigns Coal Tar Pitch Volatiles to their category "Ala - Human Carcinogens."

Exposure limits for most of the specific PAH compounds listed above have not been set by OSHA or ACGIH.

TLV-TWA represent the time weighted average concentration for a 8-hour workday and 40 hour work week to which nearly all workers may be exposed day after day, without adverse effect. The TLV-STEL represent the 15-minute time weighted average exposure (used to supplement the TLV-TWA) which should not be exceeded at any time during a workday, even if the eight-hour time weighted average is within the TLV. The OSHA PEL are those 8-hour time weighted average exposure limits which have been adopted by OSHA under 29 CFR 1910.1000.

The primary exposure pathways of concern for these compounds are inhalation and skin absorption. Methylene chloride, naphthalene, and ethyl benzene are somewhat volatile and exposure to these substances may possibly occur in the vapor state as well as with contaminated particulate. The rest of these compounds are relatively non-volatile and the major concern with airborne exposure is with dust contaminated with these compounds.

Since no piles of waste material currently exist on the surface of the South Cavalcade site, and since past surveys indicate a lack of airborne contamination, airborne exposure to contaminants prior to site drilling operations should be minimal. Potential exposure to workers may occur during site drilling and monitoring well installation.

6.3 Air Monitoring

Air quality monitoring is an integral part of the Health and Safety Program; the collected data serve as input to decisions regarding worker protective measures, routine work procedures and emergency events. The air quality monitoring program requirements can be defined as follows (Table 6-1):

- o Real-time measurement of total organic vapor concentrations.
- o Initial ambient air monitoring program.

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TABLE 6-1

AIR QUALITY MONITORING PROGRAM SUMMARY

<u>TYPE OF MONITORING</u>	<u>FREQUENCY</u>	<u>LOCATION AND NUMBER</u>	<u>EQUIPMENT USED</u>	<u>PURPOSE</u>
23 Work Area	During all sampling operations	Active work areas (e.g., each sampling location)	Foxboro Flameionization Organic Analyzer or PID instrument	Real-time, semi-quantitative data on total organic vapors for operational and health and safety decision making
Boring and well installation	15 minute intervals during all operations	At (1) ground surface and (2) breathing level	Foxboro Flameionization Organic Analyzer or PID instrument	Documentation of organic vapor levels and determination of need to change protection action levels

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Portable instruments are used to provide real-time, semiquantitative data on total organic vapor concentrations in and around the breathing zone of workers and downwind of site activities.

During all drilling, testing, and sampling activities on site, portable photoionization detectors (PID) or equivalent will be used for monitoring organic vapor concentrations in the breathing zone. These detectors will be calibrated daily and organic vapor concentration will be monitored during each site activity. Action levels for employee protection and emergency actions will be employed based on observations related to airborne concentrations of contaminants measured during site air quality monitoring of the work area and of downwind concentrations.

The operation and field manual for the hNU Systems PI 101 Photoionization Detector and the Century Systems (Foxboro) OVA-128 Organic Vapor Analyzer is included as Appendix IV. This manual describes the operating, maintenance, calibration, and troubleshooting procedures for the use of these instruments, as well as the theory of operation, response characteristics, and sensitivity.

The Health and Safety Officer or his designated assistant will document the air quality measurements daily, including corresponding meteorological data and site work activities.

6.4 Personnel Protective Equipment

Personnel protective equipment specific to each of the major task areas are outlined in Tables 6-2 through 6-4. The format permits assembly of a complete, task-specific health and safety plan for each activity.

Within the working area, organic vapor measurements at breathing level will be used to effect rapid response to airborne contaminant levels. Action limits have been established for organic vapor readings. A response scheme has been devised, defining general actions to be taken at observed sustained concentrations of organic vapors above background levels during area monitoring. "Sustained"

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indicates elevated concentration in the breathing zone for longer than 15 minutes. The basic responses to air concentrations observed during area monitoring are as follows:

- o Level I - Less than 10 ppm above background: Respirators are not required.
- o Level II - OV concentration of 10 to 50 ppm above background: Require MSHA/NIOSH approved half-face respirators with organic vapors/acid gas cartridges. Also to be worn when an obvious "dust cloud" has been generated and workers are required to continue working within the "dust cloud".
- o Level III - OV concentration exceeds 50 ppm above background: Personnel will be relocated and operations will be temporarily suspended until concentration decreases. If OV concentration remains greater than 50 ppm above background, other action will be considered including the use of full-face respirators and increased skin protection (e.g., Level C protection - see Appendix V).

The 10 ppm response level for the use of half-face respirator is based on the TLV-TWA for naphthalene, which has the lowest exposure limits (in the vapor state) of the contaminants of concern. By making the assumption that all observed organic vapor concentrations are attributable to naphthalene, a margin of safety is hereby included to account for the contribution of other unknown contaminants (with high exposure limits).

Organic vapor concentration measurements at the South Cavalcade site may be affected by natural background levels from the trucking operations (i.e., diesel exhaust). It may therefore become necessary to adjust the above action levels after more information about background concentrations is obtained.

Employees will be informed of need for a change in the level of protection required via word of mouth. Upgrading the level of protection will be performed in the decontamination area.

TABLE 6-2

PERSONNEL PROTECTIVE EQUIPMENT
FOR MONITORING WELL INSTALLATION

REQUIRED

- Work coveralls
- Safety glasses or goggles
- PVC undergloves
- Steel toe and shank footwear
- Hard hat

CONTINGENCY

- Sun screen
- At least one half-face respirator (MSHA/NIOSH approved) for each person at the drilling site, with organic vapor/acid gas (OV/AG) cartridges and dust filters.
- Portable eye wash station
- First aid kit
- Fire extinguisher and blanket
- Disposable overboots
- Ear protection
- Neoprene Gloves
- Tyvek disposable coveralls

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TABLE 6-3

PERSONNEL PROTECTIVE EQUIPMENT FOR
SOIL SAMPLING, GROUNDWATER SAMPLING, PERMEABILITY TESTING,
GEOPHYSICAL SURVEY, AND NONSOIL MATERIALS INVESTIGATION

Required

- Work coveralls
- Safety goggles
- PVC undergloves
- Steel toe and shank footwear

Contingency

- Sun screen
- At least one half-face respirator (MSHA/NIOSH approved) for each person at the site with organic vapor/acid gas (OV/AG) cartridges and dust filters
- Portable eyewash station
- First aid kit
- Disposable overboots
- Fire extinguisher and blanket
- Neoprene gloves
- Tyvek disposable coveralls

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TABLE 6-4

PERSONNEL PROTECTIVE EQUIPMENT FOR SURFACE WATER
AND SEDIMENT SAMPLING

REQUIRED

- Work coveralls
- Safety glasses or goggles
- Rubber boots
- PVC undergloves

CONTINGENCY

- Sun screen
- At least one half-face respirator (MSHA/NIOSH approved) for each person at the site with organic vapor/acid gas (OV/AG) cartridges and dust filters
- Portable eye wash station
- Neoprene gloves (mid-arm)
- Tyvek coveralls
- First aid kit

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If a particular job function appears to result consistently in high employee exposure (i.e., more than the TLV), rotation of workers, additional employee training for improved work habits, and/or other administrative action will be taken to reduce chronic exposure levels.

6.5 Health and Safety Plan-General Population

For the purposes of this investigation, the "general population" will be defined as those individuals not associated with the field activities of the remedial investigation but could be in close proximity to these activities. For the South Cavalcade site, this would include trucking firm personnel and people in the surrounding community.

The Health and Safety Plan for these groups consists of: (1) limiting the potential interaction with these groups, and (2) instituting a system of "Perimeter Action Levels", based on air monitoring of the specific field activity, whereby organic vapor concentrations at the perimeter of the field activity are closely monitored to dictate health and safety actions.

6.5.1 Limiting Interaction

Careful pre-planning of field activities will prevent significant interaction with the general population at the South Cavalcade site. Regarding trucking firm personnel, field activities can be scheduled during off-shift hours or weekends to limit the number of personnel onsite. In cases where it will be unavoidable to limit interaction with trucking personnel through scheduling, the Field Coordinator will meet with trucking firm management prior to field activities. The nature of the activity, the time required to complete the activity and the health and safety issues will be discussed. Without limiting the firm's ability to continue operations, it may be possible to exclude personnel from areas where field activities are being conducted. This will require management cooperation and will need to be addressed on a case-by-case basis.

Offsite field activities will include soil boring, monitoring well installation, and subsequent sampling activities. Pre-planning and judicious choosing of offsite field activity locations will be employed to minimize interaction with the general population in the surrounding community. The selection of "public" areas such as along streets, sidewalks, and rail lines versus residential property will be evaluated so as to minimize public interaction.

Any contaminated equipment from off-site field activities will be double-bagged in the immediate vicinity of the work area. Badly contaminated clothing such as boots, gloves, and coveralls may also be removed and double-bagged in the immediate work area. A truck or van will transport field personnel and equipment directly from the offsite work area to the field headquarters area for decontamination.

Private, offsite industrial property locations such as east and south of the site will be addressed in the same fashion as with the onsite trucking firms. The owners/management will be consulted, field activities discussed and a mutually agreeable location and time period to conduct the activity will be chosen. Management cooperation in restricting personnel access to these areas will be sought.

Automobile traffic and pedestrian patterns and volumes will be evaluated prior to commencing field activities in public areas. Field activities will be scheduled for time periods exhibiting reduced traffic and pedestrian volume. Optimal time periods may be between morning and afternoon "rush hours" or may be during weekends.

In addition to pre-planning and scheduling as a means to limit general population interaction, each offsite field activity location will be "roped off" by means of orange ribbon surrounding the perimeter of the field activity. Where possible, a 10 ft. minimum radius will be maintained for the field activity area. This will provide a physical barrier to prevent individuals from coming in close proximity of the activity area. The establishment of this perimeter will also delineate the extent of field activity air monitoring and subsequent action levels to protect the general population health and safety.

Vistors to the site will be required to report to the field headquarters and sign a log sheet prior to entering the site. Depending on the purpose of the visit and the areas of the site to be visited, the field Health and Safety Officer will determine what personnel protective equipment is required to be worn by the visitor.

6.5.2 Perimeter Action Levels

When field personnel observe a sustained OV reading in excess of 5 ppm above background level as measured in the worker breathing zone, another measurement will be taken downwind at the perimeter. The following responses will be initiated dependent upon the perimeter, sustained OV reading:

- o 5-10 ppm above background - Notify Field Coordinator and keep apprised of status; continue site work.
- o 10-25 ppm above background - Alert field personnel in the vicinity; require MSHA/NIOSH approved half-face respirators with organic vapor/acid gas cartridge and approved cartridge filter on all field personnel down wind of the work area. Monitor with OVA or HNu at the perimeter on a continuous basis.
- o 25 ppm or greater above background - Suspend all field activities, notify Field Coordinator. If concentrations greater than 25 ppm above background persist after operations are suspended, the Field Coordinator will notify the project manager and the EPA and the source of the organic vapors will be investigated. Appropriate actions will be determined on a case by case basis through discussion between Koppers and the EPA.

These perimeter action levels may be adjusted after more information is obtained on the background concentration of diesel exhaust from nearby trucking operations.

In all probability, the work area action levels described in Section 6.4 will trigger responses to elevated organic vapor concentrations before the perimeter action levels described above.

It should be noted that thorough preplanning and scheduling may result in no general population in proximity to the field activity, but the action levels described above are sufficiently conservative to be applied to all offsite, field activities.

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7.0 EMERGENCY PROCEDURES

7.1 The following emergency equipment shall be available on-site;

- o First-Aid Kit (Interex Catalog #62-122X or equivalent)
- o Fire Extinguisher
- o Fire Blanket
- o Stretcher
- o Eye-Wash Station
- o Deluge Shower

7.2 General-Injury

- o Step 1 - First Aid, as appropriate
- o Step 2 - Arrange for off-site assistance and/or medical help, if appropriate (see Table 7-1).
- o Step 3 - Notify Health and Safety Officer and Project Manager

7.3 Specific Treatments

- o Eye Exposure
 - Immediately flush exposed eye with copious amounts of water, using emergency eye-wash station.
- o Skin Exposure
 - Wash immediately with soap and water.
- o Inhalation
 - Move person to clean air. Perform artificial respiration if necessary
- o Swallowing
 - Contact poison control center, follow their instructions.

7.4 Fire

- o Localized, controlled
 - use chemical fire extinguisher and fire blanket to extinguish. Throw soil on fire as added dampening.
- o Uncontrolled
 - Evacuate Area
 - Contact fire department immediately

7.5 Responsibility

The following personnel are responsible for on-site coordination of emergency procedures:

Field Coordinator - (to be assigned prior
Health and Safety Officer - to site investigation)

These people will be responsible for initiating emergency response procedures and allocating resources to conduct spill containment or other emergency operations.

7.6 Communication

Due to the size of the site, communication between the field headquarters and field workers may be done via 2-way radio communications. In addition, verbal communication at the site can be impacted by on-site background noise and the use of personal protective equipment. For effective communication, commands will be prearranged and additional audio or visual cues will help to convey messages.

At the site, personnel will use the following internal communication code:

<u>Device</u>	<u>Type of Communications</u>	<u>Signal</u>
2-Way Radio	To each other	Assigned radio number
	To field HQ/non emergency	Assigned radio numbers
	To field HQ/emergency	Code red/assigned number
Compressed Air Horn	To field/non emergency	One long, one short blast
	To field/emergency	3 long, 3 short blasts
Siren	To field/emergency Evacuation ordered	Continuous blast

<u>Device</u>	<u>Type of Communications</u>	<u>Signal</u>
Visual	To each other	Arms waved in circle
	Distress/need assistance	over head
	Break, lunch, end of day	Two hands together break apart
	Contaminated air/strong odor	Hands clutching throat
	To field/evacuate area	Arms waved in circle over head

7.7 Entrance/Exit and Phone Locations

Site entrance and exit points will be via trucking firm plant entrances and exits located on Collingsworth and Cavalcade Streets. A phone will be located in the site field office.

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TABLE 7-1
EMERGENCY INFORMATION

In the event of a fire, uncontrollable chemical spill, explosion, or any occurrence that might be harmful to personnel or adjacent property, immediate notification of the proper emergency service will be required. The proper emergency service is determined by the nature of the emergency.

EMERGENCY NOTIFICATION

City of Houston Fire Department	(713) 227-2323
City of Houston Police Department	(713) 222-3131
Harris County Health Department	(713) 342-8685
Texas Department of Water Resources	(713) 479-5981
EPA Regional Office (Mr. John Cochran)	(214) 767-9763
State Police	(713) 463-8261
Citizens General Hospital	(713) 691-3531
7407 North Freeway-Houston	
Ambulance Service	(713) 222-3434
Poison Control Center	(713) 654-1701

PROCEDURE FOR REPORTING INCIDENTS

Immediately Call: (Kopper's Contact) Shannon Craig (412) 227-2881
James Campbell (412) 227-2689

Subsequently Contact:

John Cochran (USEPA): (214) 767-9763

001508

APPENDIX I

INTERIM SITE CHARACTERIZATION REPORT

001509

INTERIM SITE CHARACTERIZATION
REPORT
FOR
SOUTH CAVALCADE STREET
HOUSTON, TEXAS

REMEDIAL INVESTIGATION/FEASIBILITY STUDY

001510

COMPANY CONFIDENTIAL

This Work Plan, prepared by the REM II Team in accordance with the
items of USEPA Contrac No. 68-01-6939 is Company Confidential.

Work Assignment No.: 47-6L56
Document No. 143-WP1-RT-ATEX-1

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1.0 INTRODUCTION

This Interim Site Characterization Report has been provided in accordance with Task 1, Subtask 1.1 of the January 18, 1985, Work Plan Memorandum prepared by CDM for the South Cavalcade Street Site. The purpose of this subtask is to provide a description of the current situation of the South Cavalcade Street Site in relation to the site's Hazardous Ranking System Score of 38.7 on the National Priority List (NPL). Data pertinent to the site and its contamination problem were gathered, organized, and reviewed.

Major issues addressed in this report are as follows:

Site Background

Provides a summary of the regional location, pertinent area boundary features, existing ownership and use (subdivision of the property), and the general physiography, hydrology, and geology of the site, from secondary sources.

Nature and Extent of Problem

Summarizes the actual and potential onsite and off-site health and environmental effects that can be anticipated from pre-remedial investigation sources. This may include, but is not limited to, the types, physical characterization and amounts of any hazardous substances; and the potential pathways of exposure, contaminant release, and human exposure.

History and Response Actions

Describes any previous response or remedial actions conducted by either local, state, federal, or private parties, including site inspection, technical reports and their results.

2.0 BACKGROUND

2.1 SITE LOCATION AND HISTORY

The South Cavalcade Street Site is located within the incorporated boundaries of the City of Houston, Texas, the state's largest city and the fifth largest in the nation.

The site covers about 69 acres in northeast Houston, about one mile southwest of the intersection of Interstate Loop 610 North and U.S. Route 59 (Figure 2-1). The site is bounded on the north by Cavalcade Street, to the south by Collingsworth Street, on the west by the Houston Belt and Terminal (HB&T) Railroad Passenger Main and Maury Street, and on the east border by the HB&T Freight Main (now the Missouri and Pacific R.R.)

The National Lumber and Creosoting Company (NLCC) operated a wood treatment facility on the site from 1911 to 1939. An early aerial photo of the site (1933) indicates the actual wood processing/treatment facilities used by the NLCC were concentrated in the southern end of the site along Collingsworth Street, with wood storage yards occupying the remaining southern and central parts of the site and vacant (idle) lands in the northern third. A neighboring commercial development of about three acres, immediately across the Houston Belt and Terminal (HB&T) Railroad main to the west of the site, and also fronting on Collingsworth Street, shows on the 1933 photo as well. This property is identified at a later (and expanded acreage) stage as a Mobil Oil Company products distribution center (wholesale).

In 1940, the Koppers Company, Inc. (KCI) acquired the property from NLCC and operated a wood treating facility and coal tar distillation facility on the site from 1940 to 1961. Aerial photos of the site during the period of KCI operations (1944 and 1953) indicate only minor changes in site development or use from the 1933 photo. The 1953 aerial photograph shows an expansion of the Mobil Oil Company operations across the tracks west of the site to about 10 acres, including the addition of a tank battery and rail siding at the north end of the Mobil site approximately 1,000 feet north of

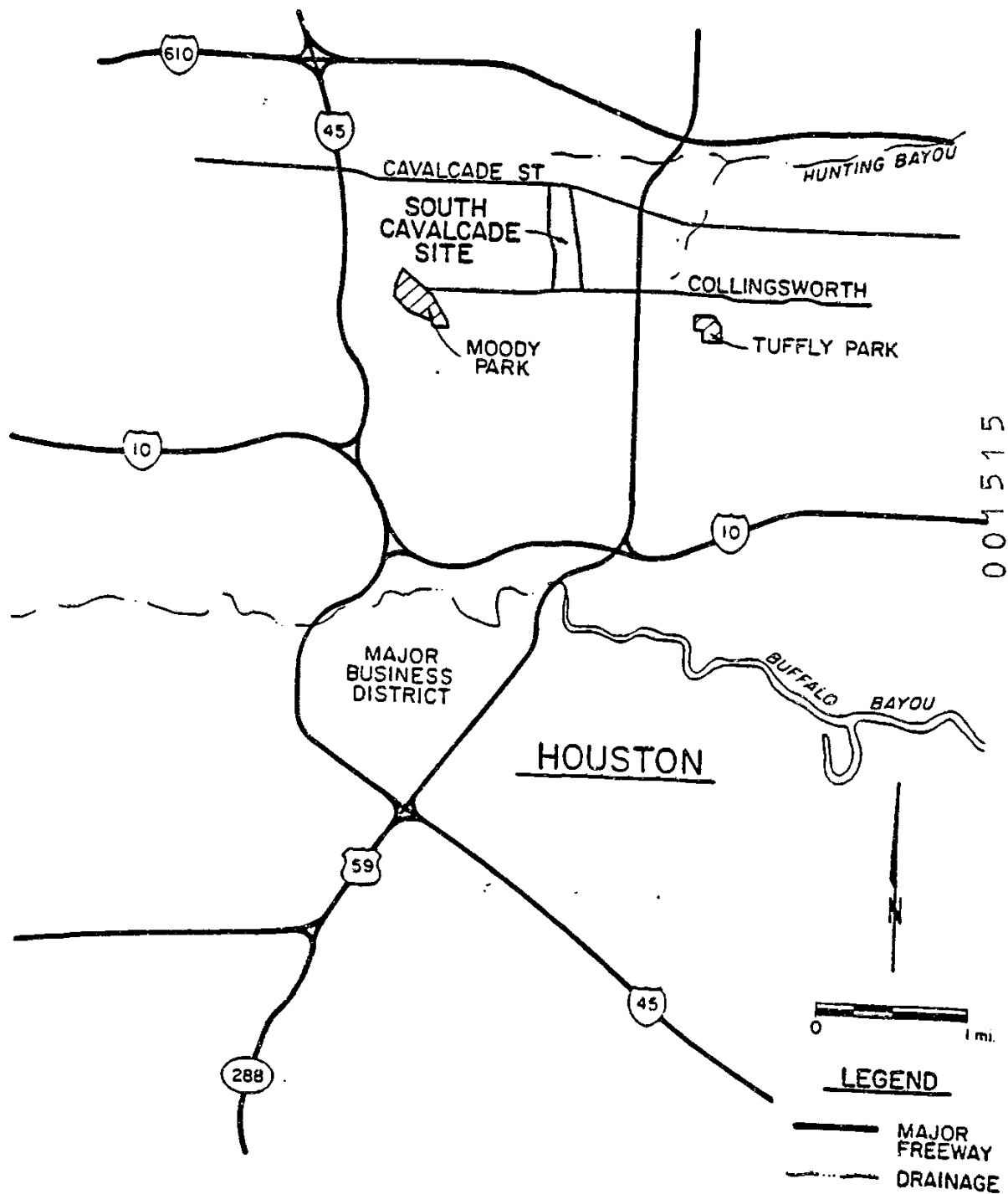


FIGURE 2-1
SITE LOCATION MAP

CAMP DRESSER & MCKEE INC.

Collingsworth Street. Also, by 1953 some commercial development had begun just to the north of the South Cavalcade Site. Although not confirmed through deed records, interviews with early Koppers Company personnel, previous owners and local residents indicate the probability of a smaller scale wood treatment operation just north of the present day Cavalcade Street in the early 1950's.

The KCI property south of the present day Cavalcade Street was transferred by recorded deed to Merchants East Motor Lines (Meridian Transport Company) in 1962. The property was subsequently subdivided into three ownership tracts, as shown previously on Figure 2-2. A northern portion of about 22.5 acres was transferred to the Baptist Foundation of Texas. This tract has been leased and developed by the Transcon Trucking Lines, with a sub-lease to AJF Leasing, Inc.

A central tract of about 18.2 acres remains in the ownership of the Meridian Transport Company and is presently undeveloped and idle. The southern tract of about 28.3 acres was subdivided into two tracts after its acquisition by Meridian Transport Company in 1962. The southeastern 13.4 acres is owned by Rex Reed and presently used by Palletized Trucking, Inc. The southwestern tract of 14.9 acres remains in the ownership of Meridian Transport Company and is developed for use of the Merchants East Motor Lines.

The Houston Metropolitan Transit Authority (MTA), as part of its proposed METRO Stage One Regional Rail System (RRS) study, investigated the feasibility of including the property designated in this report as the South Cavalcade Street Site as a yard, shop and terminal facility for the RRS. Under contract to the Houston Transit Consultants (HTC), prime contractor to the MTA, the firm McClelland Engineers, Inc. (MEI) was selected to perform a geotechnical investigation of the site. During the course of that investigation, observations were made of probable contamination of the site with toxic waste materials from previous commercial or industrial users.

At that time (early 1983) the state agency responsible for hazardous waste control, the Texas Department of Water Resources (TDWR), was notified of the probable contamination of the site. The TDWR then initiated the state's process of investigation to determine the nature and extent of the problem, the present and prior ownership and use of the site, and the possibility of voluntary compliance with remedial clean-up operations at the site.

At the same time, the Houston MTA, acting through HTC and its geotechnical consultant MEI, contracted with the environmental engineering and consulting firm Camp Dresser & McKee Inc. (CDM) to perform a comprehensive contaminant survey of the site. A CDM report entitled "Cavalcade Contaminant Survey" in three volumes, dated July 11, 1983, provided the first detailed assessment of the extent and nature of hazardous contamination at the Cavalcade Site. 00100

In April, 1984, the TDWR recommended the site to the U.S. Environmental Protection Agency (EPA) for inclusion on the National Priority List (NPL) of hazardous waste sites. On October 2, 1984, the South Cavalcade Site was placed on the NPL, with EPA taking the lead responsibility for subsequent RI/FS efforts. The site has been assigned a Hazardous Ranking System score of 38.7 on the NPL.

In response to initiatives by the TDWR to secure remedial measures by previous owners of the site, the Koppers Company of Pittsburgh, Pennsylvania contracted with the Houston geotechnical consultants McClelland Engineers, Inc. (MEI) to perform further site investigations. An MEI report to Koppers, dated May 8, 1984, presents the results of that site study. Subsequently, Koppers contracted with the firm Environmental Research and Technology, Inc. (ERT) of Pittsburgh, Pennsylvania to propose a work plan for a RI/FS study on Koppers former Cavalcade Plant Site. A draft "Proposed Work Plan, Remedial Investigation/Feasibility Study, Koppers Company, Inc. Former Cavalcade Plant Site, Houston, Texas" dated December 13, 1984, presents a proposed RI/FS program for the Koppers Company.

In December, 1984, EPA authorized a work assignment for an RI/FS on the South Cavalcade Street Site to CDM under project REM II - EPA Contract No. 68-01-6939/143/WP1, Document Control No. 143-WP1-WA-ANNM-1. A Work Plan Memorandum by CDM for RI/FS on the South Cavalcade Street Site, dated December 31, 1984, has been submitted to the EPA.

2.2 CONTAMINATION PROBLEM

The South Cavalcade Street Site has a 70+ year history of industrial/commercial use with potential for long term contaminant pollution of the site. A report "Cavalcade Contaminant Survey", in three volumes by Camp Dresser & McKee, Inc. dated July 11, 1983, first documents the general nature and extent of site pollution. Section 3.0 presents review of data in this report.

2.3 DESCRIPTION OF NATURAL FEATURES OF THE SITE

Present Land Use

The present land use of the South Cavalcade Street Site is predominately commercial, made up of several trucking firms. A southern tract of about 28.3 acres, facing onto Collingsworth Street to the south, is presently occupied by the Merchants Fast Motor Lines (14.9 acres in the ownership of Meridian Transport Company) on the southwest side of the tract, and 13.4-acres to the southeast owned by Rex King and occupied by Palletized Trucking, Inc.

A central tract of some 18.2 acres is also owned by the Meridian Transport Company and is presently idle (undeveloped) land. The 22.5 acre northern tract is owned by the Baptist Foundation of Texas and presently occupied by the Transcon Trucking Lines and AJF Leasing, Inc. The northern tract accesses to the north onto Cavalcade Street. Figure 2-2 displays the present property ownership of the site.

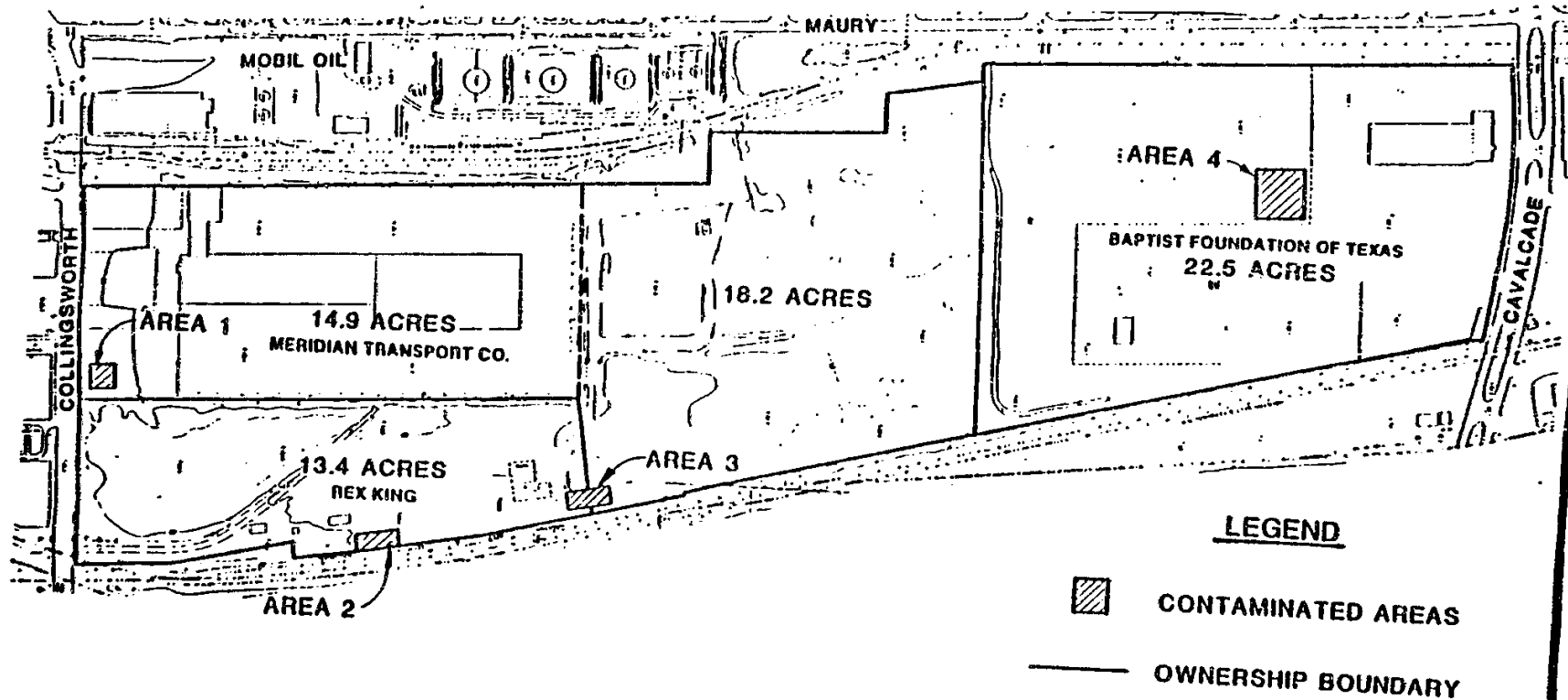


FIGURE 2-2
PRESENT OWNERSHIP & USE WITH CONTAMINATION AREAS

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Physiography

The general physiography of the site is a relatively flat plain with a very gentle slope to the south and east. Elevations range from about 50.0 feet mean sea level (msl) on the south to about 52.1 feet msl along Cavalcade Street to the north, an average slope of less than 0.15 percent. Drainage is generally to the south and east to local tributaries of Buffalo Bayou and the Houston Ship Channel.

Soils

Local soil conditions have previously been investigated at the South Cavalcade Site (see McClelland Engineers Report No. 0182-0282, Volume II, dated May 20, 1983). A generalized soil profile of the site shows four distinct soil strata. Figure 2-3 depicts the soil conditions throughout the site based on reconnaissance borings. Although there are variations in strata elevation and thickness, the following generalized soil strata appear to the present throughout the site:

<u>Strata</u>	<u>Depth, ft.</u>	<u>Description</u>
I	0-2	Fill: silty fine sand
II	2-10	Soft to very stiff sandy clay and clayey sand
III	10-20	Medium dense to very dense fine sand
IV	20-80	Very stiff to hard clay and silty clay, with sand and silt layers

Figure 2-3 also indicates the presence, at the time of the reconnaissance soil borings in early 1983, of shallow water table conditions at depths of one to five feet beneath the surface throughout the site. The shallow sand strata (strata III in Figure 2-3) appear to be consistently present throughout the site and have a regional extent and significance off-site as well, as indicated by Figure 2-4. Typical shallow sand layers common to the Texas Gulf Coast area usually contain various amounts of silt. The relative permeability for sand strata will depend largely on the silt content, which varies significantly from place to place. Permeabilities will need to be determined on a site-by-site basis.

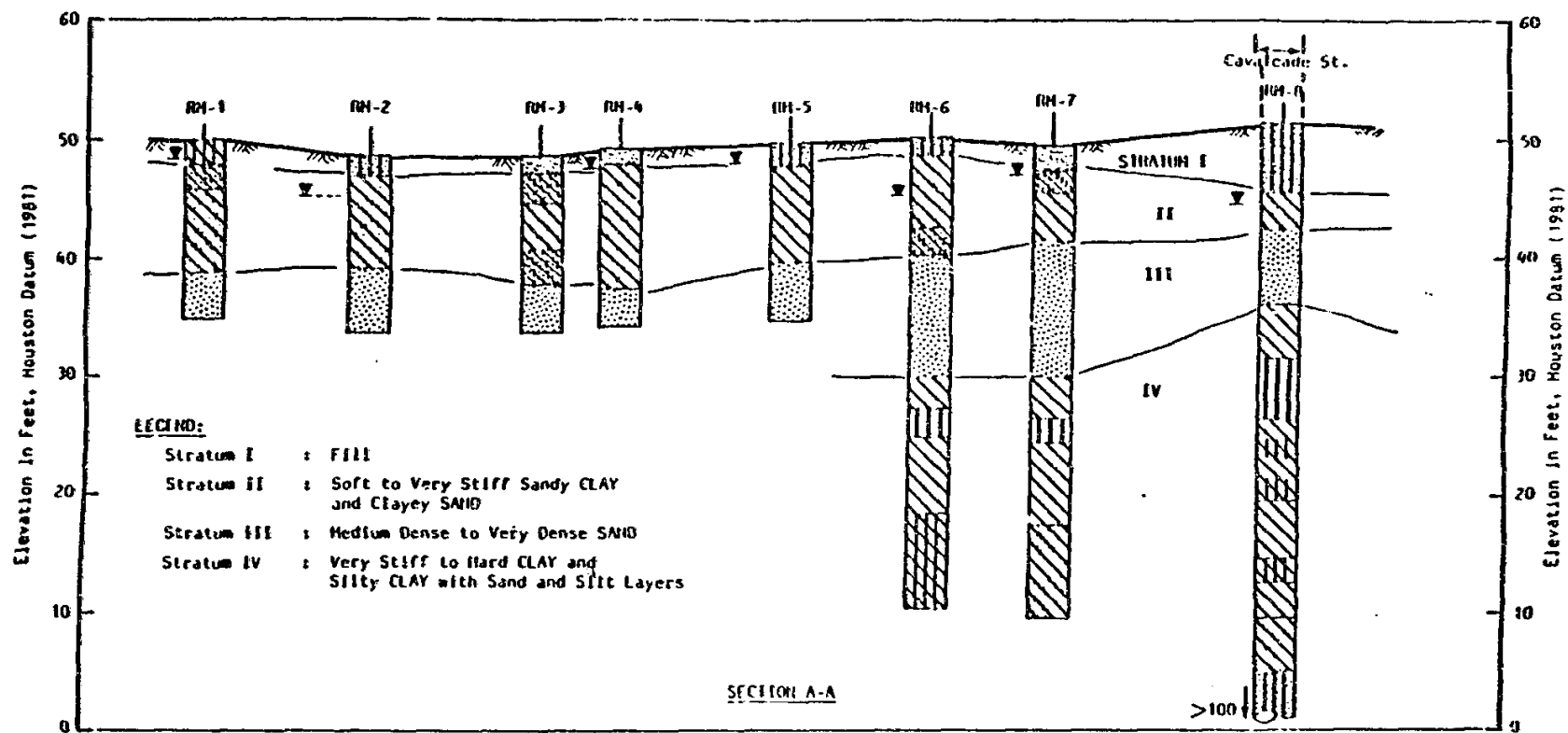
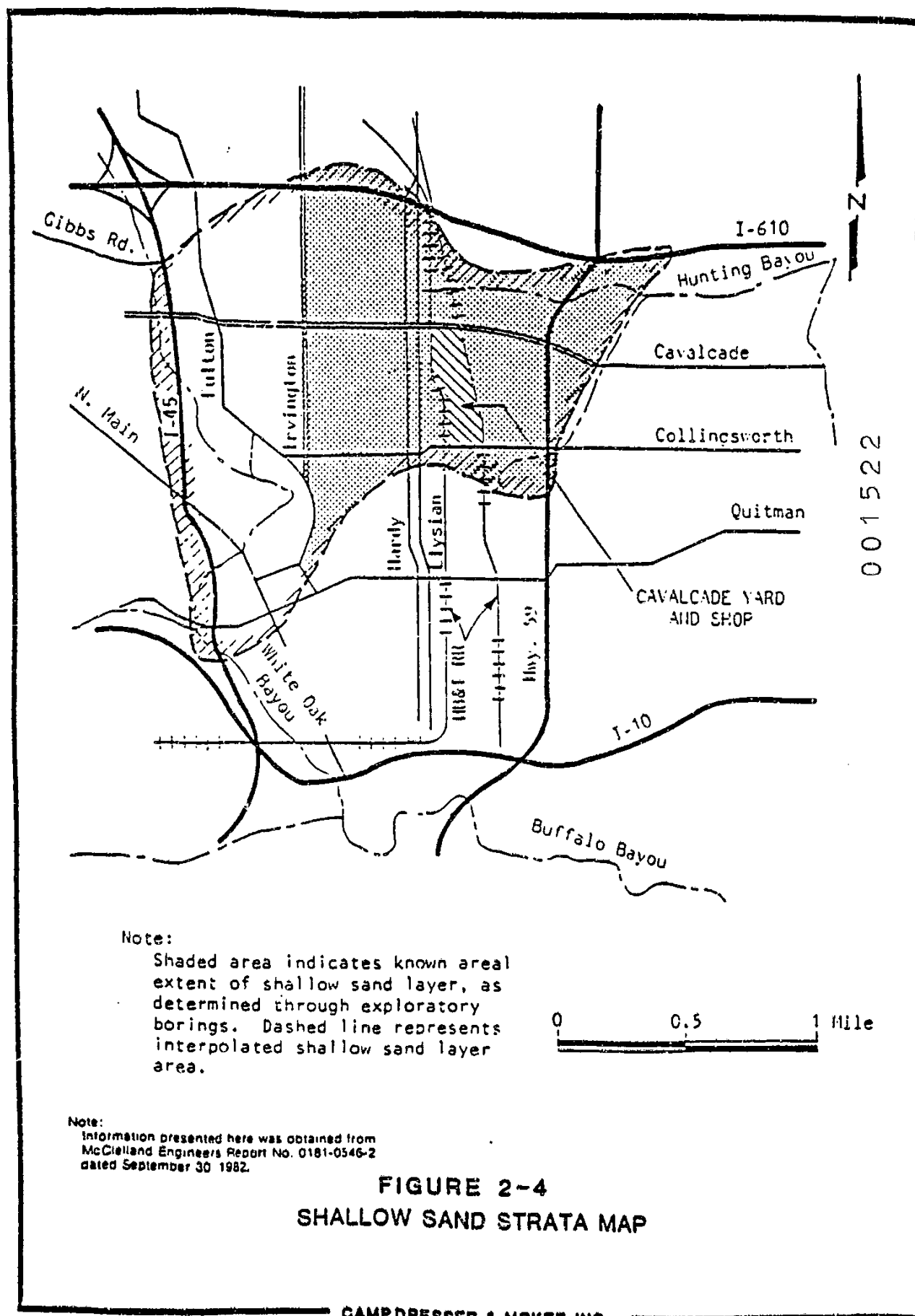


FIGURE 2-3
SOIL BORINGS & GENERALIZED SOIL PROFILE

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Geology

The geologic strata underlying the South Cavalcade Site consist principally of interbedded sands, silts, and clays of the Beaumont Formation, deposited in fluvial (river) and deltaic environments of the Pleistocene Epoch. Clay and silt materials predominate in the upper 200 to 300 feet of the Beaumont Formation, with thin discontinuous layers of sand occurring randomly. Thicker, more continuous sand deposits that occur in deeper parts of the Beaumont, also show extensive sand deposits in the upper strata of the formation.

Hydrology

Both the Lissie Formation and the lower Beaumont Formation are common sources of groundwater supplies in the Houston area although yields are small and considered inadequate for major exploitation. The deeper sands of the Chicote and Evangeline Aquifers, at depths of over 1,000 feet, are the local sources for major groundwater supplies.

11 The Beaumont Formation dips generally to the southeast. The regional dip of the strata and the presence of the interbedding sands and clays influence the regional hydrogeology of the entire area. Published geologic literature indicate that the principal areas of recharge for the Chicote and Evangeline Aquifers occur several miles north of the site area.

The predominately clay and silty soils in the upper strata of the Beaumont Formation, in conjunction with the southeastward dip of the formation, serve as a confining layer for the underlying Chicote Aquifer, producing artesian groundwater conditions in the aquifer. Discontinuous sand layers in the overlying Beaumont are considered too limited for effective recharge to the deeper aquifers.

Drainage

Surface drainage from the site consists of a system of poorly defined surface ditches, with storm water inlets and catch basins to convey runoff into the storm sewer system from the more developed areas on the south and north ends of the site. The undeveloped central part of the site is poorly drained, with surface ditches draining to runoff ditches along the east and west property borders in the railroad right-of-ways.

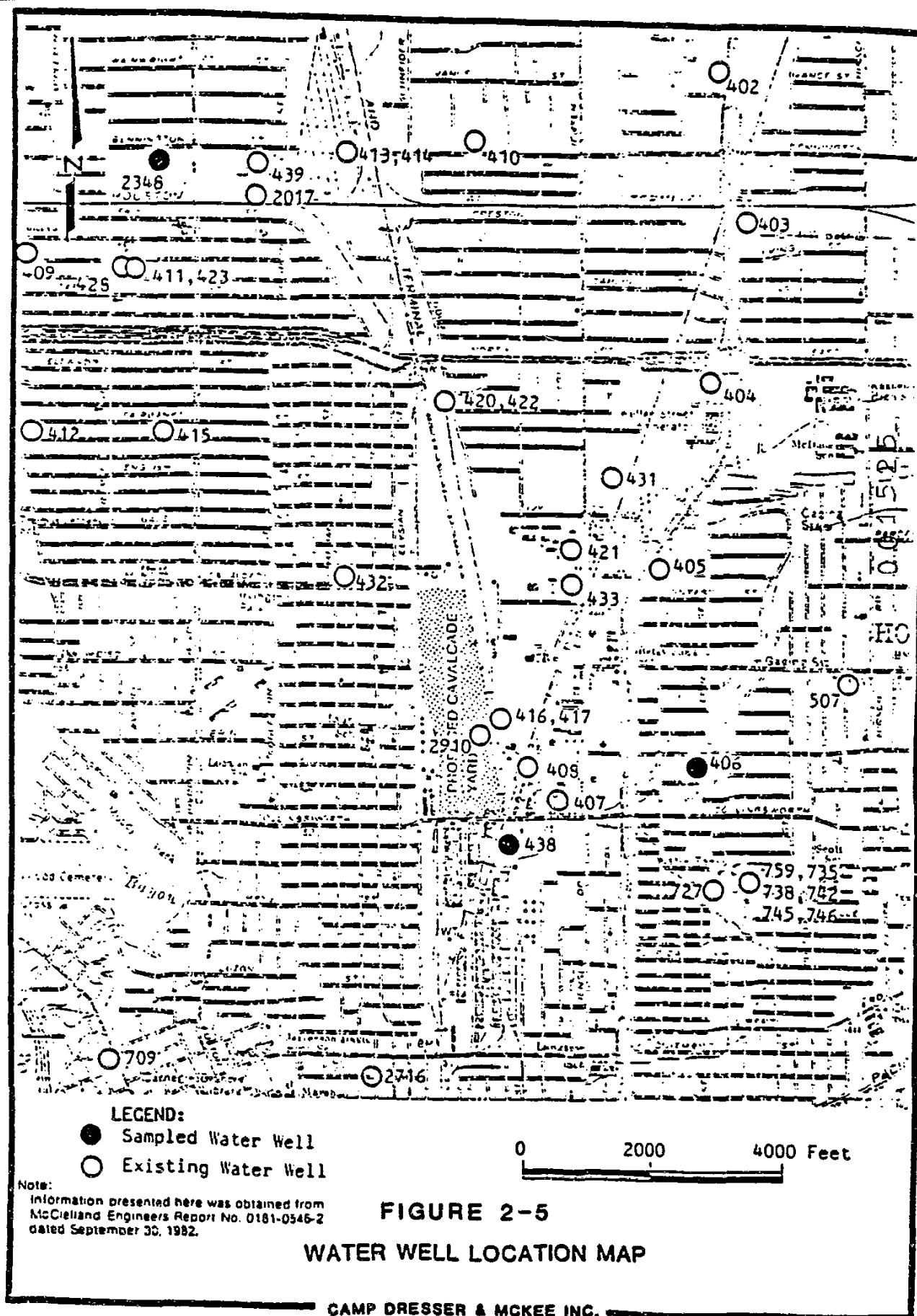
The southern two-thirds of the site drain generally to the south and east into a southern extension of Hunting Bayou, while the northern third drains to the east directly into Hunting Bayou. Hunting Bayou is a tributary to the Houston Ship Channel several miles downstream of the site.

Groundwater

A survey of existing water wells in the vicinity of the South Cavalcade Site was conducted for the earlier McClelland Engineers study (report No. 0181-0546-2, dated September 30, 1982). Figure 2-5 depicts the location of existing wells in relation to the site. Three common strata used for groundwater supplies in the site area were identified. The more shallow of the local aquifers is located at elevations of about 170 to 220 feet below ground surface. This aquifer does not have a high yield and is restricted primarily to domestic uses. The second aquifer is found approximately at depths of 400 to 600 feet. This aquifer is developed locally for mainly industrial purposes. A third aquifer is located typically below 1,000 feet and is used primarily as a municipal supply for the City of Houston.

Faulting

The Pecore Fault is the only known active fault in the vicinity of the South Cavalcade Site. The fault trends approximately east-west and intersects the surface just north of Cavalcade street in the immediate vicinity of the site. The approximate mapped location of the Pecore Fault in the site vicinity is shown on Figure 2-6. The predicted annual differential movements across the fault are about 0.4 inches vertical and 0.1 inch



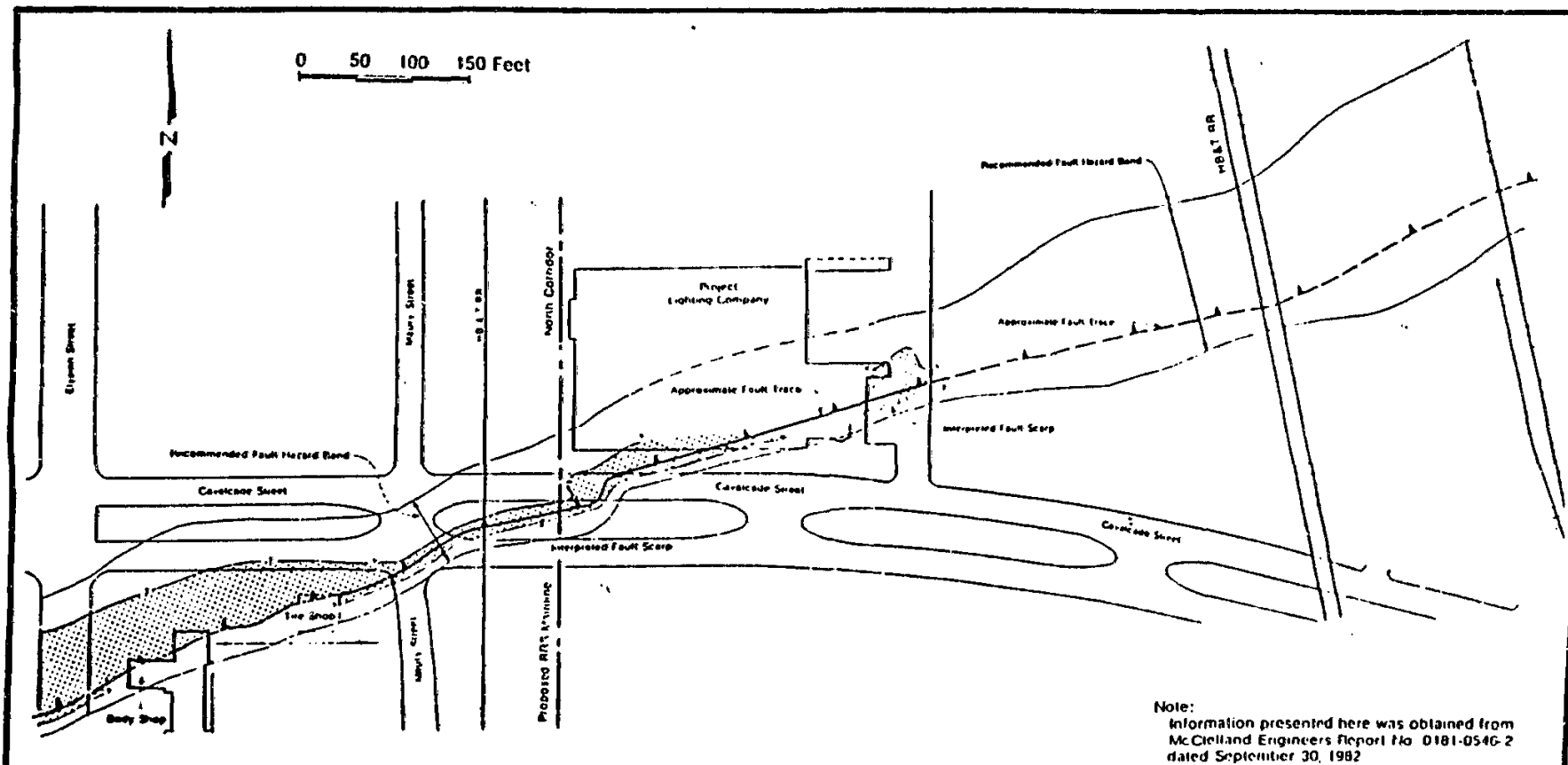


FIGURE 2-6
PECORE FAULT LOCATION

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CAMP DRESSER & MCKEE INC.

horizontal. Many faults in the Houston area tend to act as partial hydrogeologic barriers to groundwater movements. Isolated portions of an aquifer may thus have different hydrogeologic characteristics due to local faulting. The extensive withdrawal of groundwater and petroleum supplies in the greater Houston area, resulting in active land subsidence, has caused accelerated fault movements during recent years.

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3.0 REVIEW OF EXISTING INFORMATION

A preliminary description of contaminants found at the South Cavalcade Site by previous investigations provides a basis for future remedial investigations. Any actual or potential health or environmental hazards already identified will be described as to types, physical characteristics and quantities, if known. The most probable pathways of exposure and escape of hazardous materials will also be described.

Recent 1982-83 investigations of the South Cavalcade Street Site for the Houston Metropolitan Transit Authority (MTA) revealed areas of localized soil and shallow groundwater contamination. McClelland Engineers, Inc. (MEI) performed a reconnaissance geotechnical survey in 1982 for MTA in relation to then pending plans for a Metro Regional Rail System (RRS). The MEI survey included general soil borings and preliminary foundation investigations for the proposed RRS yard and shop facility at the Cavalcade Site. 001528

Creosote odors were detected during the MEI investigations and soil and groundwater samples were collected for analysis. Trace amounts of naphthalene and phenanthrene were identified and it was subsequently determined that the site was contaminated from previous wood preserving operations. It was recommended to MTA that additional investigations be conducted to assess the extent of the contamination problem.

In April of 1983, Camp Dresser & McKee, Inc. (CDM) was selected to perform a contaminant survey of the Cavalcade Site. A CDM report, in three volumes, entitled "Cavalcade Contaminant Survey", and dated July 11, 1983, provides a comprehensive assessment of their environmental study. CDM's site investigation program consisted of the following task activities for the South Cavalcade Site:

<u>TASK</u>	<u>PREFIX</u>	<u>NUMBER COMPLETED</u>
Sediment Sampling	SD	4
Surface Water Sampling	SW	2
Surface Soil Sampling	SL	4
Soil Borings	SL	10
Subsurface Soil Samples	SL	13
Shallow Observation Wells	OW	9
Deep Observation Well	OW	1
Production Well Sampling	PW	3

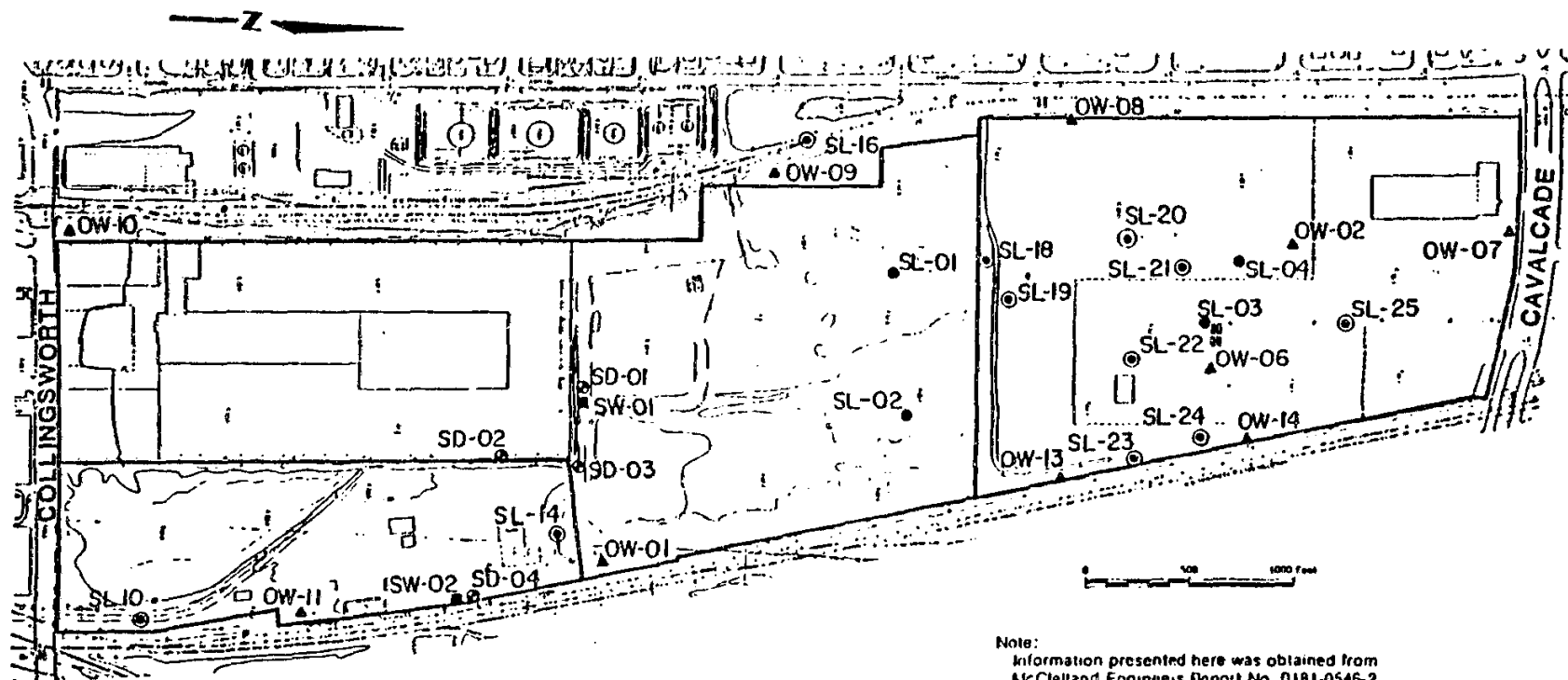
Comprehensive investigative results, methods and documentation are available in the three-volume report "Cavalcade Contaminant Survey" by CDM, in association with MEI, dated July 11, 1983. Results of the CDM contaminant survey are summarized in the following paragraphs.

3.1 SOIL INVESTIGATIONS

Soil borings at sites related to the locations of earlier wood treatment and coal tar distillation facilities during the 1911-1962 period were made to investigate subsurface contamination and migration of contaminants in the near-surface (to 40-foot depths) soil profile. All borings were confined to onsite locations. Figure 3-1 exhibits the locations of the soil boring localities.

Soil sampling depths and intervals were selected to best represent the probable pattern of contaminant concentration and movement. Sampling intervals were continuous from ground surface to 10 feet below ground surface for the deeper, 40-foot borings. Samples were taken for analysis at 5-foot intervals from the 10 to 40 feet depth. The shallow depth borings (10 feet) were at locations more remote from suspected areas of contamination and samples were taken at 2, 6, and 8-foot depths below ground surface at these borings.

In all cases, rotary drilling rigs were employed in conjunction with 3 inch thin wall Shelby tube samplers, 2 feet in length, which were attached to the bottom of the drill stem. Samples were taken by pressing the tube into undisturbed material at selected depths. The soil sampling analysis disclosed contamination with both organic and inorganic compounds in the



Note:
Information presented here was obtained from
McClelland Engineers Report No. 0181-0546-2
dated September 30, 1982.

LEGEND

- Deep Soil Sample
- Shallow Soil Sample
- Sediment Sample
- Surface Water Sample
- ▲ Observation Well

NOTE: SAMPLE LOCATIONS ARE
APPROXIMATE.

FIGURE 3-1
SAMPLING LOCATION MAP
001530

vicinity of suspected disposal areas, particularly near the soil surface. Concentrations of contaminants consistently decrease at greater depths in the soil profile.

CDM's soil boring program also provided visual and olfactory evidence of contamination in subsurface soil samples. All observations of soil contaminants were limited to areas of previously known or suspected waste disposal, with the exception of two off-site borings designated as SL-16 and SL-10 on Figure 3-1. These observations (SL-10 and 16) are probably not related to the previous users of the South Cavalcade Site, but to other commercial or industrial sources in the area.

3.2 SEDIMENT SAMPLING

Bottom sediment samples were collected from surface drainage areas at the southern end of the site. Locations of sediment sample collections (SD prefix) are shown on Figure 3-1. Detailed analytical results of the sediment sampling for toxic compounds are presented in Section 6.3, Vol. I of the CDM report. The only findings of significance were the presence of low-level refractory organic compounds, particularly the polynuclear aromatic hydrocarbons (PAH), as consistent with the site's history of wood preserving operations. Toxic metal contamination, although posing no significant environmental hazard, may prove to be a problem with respect to ultimate disposal. Results of analyses for contaminants in sediment samples are shown in Table 3-1.

3.3 SURFACE WATER SAMPLING

Two surface water samples were collected in conjunction with sediment sample locations SD-01 and SD-04. Surface water sample locations are designated SW-01 and SW-02 on Figure 3-1. No contamination of significance in local runoff water was detected at site SW-01 and only low-level contamination of PAH compounds was observed at the off-site SW-02 sample collected from runoff waters in the railroad drainage ditch. Results of laboratory analyses for contaminants in surface water samples are shown in Table 3-2.

TABLE 3-1
SEDIMENT SAMPLING ANALYTICAL RESULTS

Volatile Organics (all values PPB, ug/kg wet weight)

	<u>SD-01</u>	<u>SD-02</u>	<u>SD-03</u>	<u>SD-04</u>	<u>SD-05</u>
<u>Contaminant</u>					
Methylene Chloride	100	48	83	110	39

Refractory Organics (all values PPB, ug/kg, wet weight)

	<u>SD-01</u>	<u>SD-02</u>	<u>SD-03</u>	<u>SD-04</u>	<u>SD-05</u>
<u>Contaminant</u>					
Anthracene	240.	4700.	1600.	2100.	ND
Benzo(a)anthracene	550.	440.	620.	18000.	ND
Benzo(a)pyrene	500.	250.	600.	5400.	ND
3,4-Benzofluoranthene	1100.	890.	1300.	4800.	ND
Benzo(g,h,i)perylene	430.	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalate	210.	ND	ND	ND	ND
Chrysene	550.	530.	680.	14000.	ND
Floranthene	1100.	750.	1200.	25000.	320.
Indeno(1,2,3,-c,d)pyrene	320.	ND	600.	ND	ND
Phenanthrene	650.	ND	860.	14000.	ND
Pyrene	850.	690.	1100.	22000.	260.
Fluorene	ND	360.	ND	520.	ND
Aceraphthene	ND	ND	ND	580.	ND

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Toxic Metals and Inorganics (all values PPM, mg/Kg, wet weight)

	<u>SD-01</u>	<u>SD-02</u>	<u>SD-03</u>	<u>SD-04</u>	<u>SD-05</u>
<u>Contaminant</u>					
Arsenic (As)	2.0	2.4	1.5	2.2	1.5
Beryllium (Be)	0.2	0.6	0.3	0.5	0.2
Cadmium (Cd)	0.8	0.6	1.0	1.4	ND
Chromium (Cr)	10.0	13.0	12.0	9.7	6.8
Copper (Cu)	13.0	60.0	21.0	82.0	21.0
Lead (Pb)	61.0	88.0	69.0	185.0	20.0
Mercury (Hg)	0.025	0.043	0.032	0.006	0.006
Nickel (Ni)	4.5	4.9	5.4	2.7	2.7
Silver (Ag)	0.40	0.06	ND	ND	ND
Thallium (Th)	ND	0.06	0.97	ND	ND
Zinc (Zn)	160.0	150.0	150.0	30.0	30.0

TABLE 3-2
SURFACE WATER SAMPLING ANALYTICAL RESULTS

Volatile Organics

No volatile organics detected.

Refractory Organics (all values reported as PPB, ug/l)

	<u>SW-01</u>	<u>SW-02</u>
<u>Contaminant</u>		
Benzo(a)anthracene	ND	10.
Benzo(a)pyrene	ND	10.
3,4-benzofluoranthene	ND	21.
Benzo(k)fluoranthene	ND	21.
Chrysene	ND	12.
Di-n-butyl phthalate	ND	18.
Fluoranthene	ND	17.
Pyrene	ND	14.

Toxic Metals and Inorganics (all values removed as PPM, mg/l)

	<u>SW-01</u>	<u>SW-02</u>
<u>Contaminant</u>		
Cadmium (Cd)	0.05	ND
Zinc (Zn)	0.32	0.18

001533

3.4 SURFACE SOIL SAMPLING

Four surface soil sampling locations, designated SL-01 thru SL-04 on Figure 3-1 were inspected for contamination. All samples were collected at locations suspected of prior use for disposal of creosote or other wood preserving products. Low-levels of volatile organics were detected at all four locations, with ethylbenzene at SL-04 of minor significance. The previously identified disposal areas, represented by SL-03 and SL-04, are highly contaminated with both PAH and toxic metals at the surface. All four sites indicate that use of an onsite treatment facility is questionable due to high toxic metal assays. Table 3-3 provides the results of contaminant analyses for surface soil samples.

3.5 SUBSURFACE SOIL SAMPLING

Multiple depths at each of 13 locations were sampled to determine the depth of contamination and the structure of the underlying soil profile. Sampling locations were selected at areas suspected of containing contamination or potential areas of future excavation for the RRS. Subsurface soil sampling sites are designated with the prefix SL on Figure 3-1. Details of the subsurface soil sampling program are found in Section 6.6 of the CDM report and are presented here in Table 3-4.

The previously identified contaminant areas (SL-03 and SL-04) are highly contaminated with both organic and inorganic (toxic metals) compounds at the surface and near-surface (to 5-foot depths). The level of contamination for most compounds decreases rapidly with depth. At SL-03, the contamination from polynuclear aromatic hydrocarbons decrease by a factor of 100 at the 10-foot depth, with similar declines in inorganic contaminants except for beryllium (Be), nickel (Ni) and silver (Ag). SL-04 demonstrates a similar attenuation of contamination with increasing soil depth, but required greater soil depths (15-foot depth for PAH's and 20-foot depth for most toxic metals) for similar levels of decline. An exception is a continuing high concentration of lead (Pb) at the 20-foot depth for SL-04.

TABLE 3-3
SURFACE SOIL SAMPLING ANALYTICAL RESULTS

Volatile Organics (all values PPB, ug/kg wet weight)

<u>Contaminant</u>	<u>SL-01</u>	<u>SL-02</u>	<u>SL-03</u>	<u>SL-04</u>
Methylene Chloride	59	39	59	ND
Ethylbenzene	ND	ND	ND	160
Toluene	ND	ND	ND	23

Refractory Organics (all values PPB, ug/kg, wet weight)

<u>Contaminant</u>	<u>SL-04</u>	<u>SL-02</u>	<u>SL-03</u>	<u>SL-01</u>
Acenaphthene	100,000	ND	780.	ND
Acenaphthylene	3,000	ND	2400.	ND
Anthracene	240,000	ND	12000.	ND
Benzo(a)anthracene	17,000	ND	32000.	200.
Benzo(a)pyrene	4,600	ND	21000.	ND
3,4-benzofluorathene	10,000	ND	46000.	260.
Benzo(g,h,i)perylene	ND	ND	7200.	ND
Benzo(k)fluoranthene	10,000	ND	46000.	260.
Chrysene	11,000	ND	42000.	200.
Fluoranthene	260,000	ND	120000.	ND
Fluorene	80,000	ND	980.	ND
Indeno(1,2,3-c,d)pyrene	ND	ND	7200.	ND
Naphthalene	340,000	ND	1000.	ND
Phenanthrene	240,000	ND	2000.	ND
Pyrene	170,000	ND	110000.	10.
Di-n-octyl phthalate	ND	11	ND	ND

Toxic Metals and Inorganics (all values PPM, mg/kg, wet weight)

<u>Contaminant</u>	<u>SL-04</u>	<u>SL-02</u>	<u>SL-03</u>	<u>SL-01</u>
Arsenic (As)	0.35	2.5	82.0	1.8
Beryllium (Be)	0.29	ND	0.20	0.26
Cadmium (Cd)	0.88	ND	0.10	ND
Chromium (Cr)	12.0	7.6	79.0	14.0
Copper (Cu)	4.4	32.0	21.0	ND
Lead (Pb)	8.4	31.0	54.0	3.4
Mercury (Hg)	0.005	0.009	0.040	0.020
Nickel (Ni)	8.6	33.0	2.7	2.3
Silver (Ag)	0.7	ND	0.20	ND
Thallium (Tl)	ND	ND	0.10	ND
Zinc (Zn)	14.0	40.0	290.0	150.0

TABLE 3-4

SUBSURFACE SOIL SAMPLING ANALYTICAL RESULTS

SL-03 (All organic values PPB, ug/kg, all inorganic values PPM, mg/kg wet weight basis)

Volatile Organic	01	02	03
<u>Contaminants</u>	(2)	(5)	(10)
Methylene chloride	59	40	33

Refractory Organic Contaminants

Acenaphthene	780.	ND	ND
Acenaphthylene	2400.	280.	ND
Anthracene	12000.	1000.	ND
Benzo(a)anthracene	32000.	5600.	ND
Benzo(a)pyrene	21000.	2000.	ND
3,4-Benzofluoranthene	46000.	6800.	ND
Benzo(g,h,i)perylene	7200.	1600.	ND
Benzo(k)fluoranthene	46000.	6800.	ND
Chrysene	42000.	4500.	ND
Fluoranthene	120000.	24000.	ND
Fluorene	580.	ND	ND
Indeno(1,2,3-c,d)pyrene	7200.	1800.	ND
Naphthalene	1000.	ND	ND
Phenanthrene	20000.	5800.	ND
Pyrene	110000.	20000.	ND

SL-03	01	02	03
	(2)	(5)	(10)

Toxic Metal Contaminants

Arsenic (Ar)	82.0	1.5	0.33
Beryllium (Be)	0.20	0.20	0.20
Cadmium (Cd)	0.10	ND	ND
Chromium (Cr)	79.0	14.0	3.4
Copper (Cu)	21.0	1.9	1.3
Lead (Pb)	54.0	7.2	7.2
Mercury (Hg)	0.040	0.620	0.009
Nickel (Ni)	2.7	3.0	2.1
Silver (Ag)	0.20	ND	0.88
Thallium (Tl)	0.10	ND	ND
Zinc (Zn)	290.0	23.0	3.6

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TABLE 3-4 (continued)

SL-04 (all organic values PPB, ug/kg, all toxic metal values PPM mg/kg, wet weight basis)

Volatile Organic

	01 (2)	02 (5)	03 (10)	04 (15)
<u>Contaminants</u>				
Ethylbenzene	160	98	10	ND
Methylene chloride	ND	52	73	ND

Refractory Organic Contaminants

Acenaphthene	100000.	360000.	80000.	54000.
Acehaphthylene	3000.	ND	3200.	ND
Anthracene	240000.	520000.	48000.	58000.
Benzo(a)anthracene	17000.	27000.	28000.	32000.
Benzo(a)pyrene	4600.	7600.	32000.	46000.
3,4-Benzofluoranthene	10000.	16000.	7200.	34000.
Benzo(g,h,i)Perylene	ND	ND	5000.	ND
Benzo(k)fluoranthene	10000.	16000.	7200.	34000.
Chrysene	11000.	20000.	36000.	32000.
Dibenzo(a,h)anthracene	ND	ND	5000.	ND
Fluoranthene	260000.	440000.	120000.	20000.
Fluorene	80000.	110000.	64000.	34000.
Indeno(1,2,3-c,d)pyrene	ND	ND	ND	ND
Naphthalene	340000.	640000.	200000.	ND
Phenanthrene	240000.	1100000.	180000.	44000.
Pyrene	170000.	280000.	88000.	14000.
2,4-Dimethylphenol	ND	ND	ND	ND
SL-04				

<u>Toxic Metal</u>	01	02	03	04
<u>Contaminants</u>	(2)	(5)	(10)	(20)
Arsenic	1.8	2.0	1.2	0.29
Beryllium	0.26	0.28	0.6	0.31
Cadmium	ND	ND	0.5	ND
Chromium	14.0	4.1	8.1	3.7
Copper	ND	0.56	7.7	1.2
Lead	3.4	0.37	9.1	6.4
Mercury	0.020	0.005	0.004	0.005
Nickel	2.3	3.70	15.0	4.50
Silver	ND	ND	1.2	ND
Zinc	15.0	23.0	24.0	5.8

3.6 SHALLOW GROUNDWATER SAMPLING

Nine shallow groundwater observation wells were located on the South Cavalcade Site to determine the extent of groundwater contamination in the upper (shallowest) aquifer beneath the site and to determine the direction of flow of the local groundwater system. Selected wells located near the suspected contamination areas (OW-01 and 02) were sampled for organic contamination. During the upper (shallow) aquifer groundwater sampling program, the organic contamination detected was consistent with previously detected surficial contaminants, except for concentrations for volatile organics (benzene, ethylbenzene and toluene) observed in groundwater samples from OW-02. These aromatic hydrocarbons are more consistent with recent hydrocarbon (petroleum products) contamination. OW-01 showed no detectable volatile organics and significantly fewer and smaller concentrations of refractory organics than found in the groundwater at the OW-02 well site. Table 3-5 provides the results of contaminant analyses of the shallow groundwater samples.

The levels of toxic metal contamination found in the upper aquifer groundwater are within EPA primary and secondary drinking water standards. The high levels of toxic metal contamination found in surface soil samples at these locations are not reflected in associated shallow groundwater samples. This indicates that the toxic metals are not in mobile forms migrating downward through the soil.

The cyanide concentration observed in both wells OW-01 and OW-02 are inconsistent with any known previous industrial source at this site. The presence of cyanide in the shallow groundwater may indicate an off-site source of cyanide compounds in the area.

3.7 DEEP GROUNDWATER SAMPLING

A deep (200 foot) groundwater monitoring well, designated as OW-06 on Figure 3-1, was installed and sampled to determine the extent of possible groundwater contamination in a lower aquifer, used in the area as a source

TABLE 3-5

SHALLOW GROUNDWATER SAMPLING ANALYTICAL RESULTS

Volatile Organics (all values reported as PPB, ug/l)

	OW-01	OW-02
<u>Contaminants</u>		
Benzene	ND	21
Ethylbenzene	ND	58
Toluene	ND	110

Refractory Organics (all values reported as PPB, ug/l)

	OW-01	OW-02
<u>Contaminants</u>		
2,4-Dimethylphenol	ND	680
Pentachlorophenol	ND	66
Phenol	ND	59
Acenaphthene	49	380
Acenaphthylene	17	30
Benzo(a)pyrene	NA	29
Bis(2-ethylhexyl) phthalate	ND	17
Butyl benzyl phthalate	ND	17
Di-n-butyl phthalate	ND	34
Fluoranthene	23	34
Fluorene	73	300
Naphthalene	670	17000
Phenanthrene	160	240
Pyrene	17	27

Toxic Metals and Inorganics (all values reported as PPM, mg/l)

	OW-01	OW-02
<u>Contaminant</u>		
Arsenic (As)	ND	0.13
Copper (Cu)	0.06	ND
Zinc (Zn)	0.12	0.20
Total Cyanide (Cn)	0.70	0.10

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of domestic water supply. A representative groundwater sample was collected following well stabilization. Two soil samples were collected from soil immediately above and below the well screen depth. The groundwater samples and the two soil samples were analyzed for appropriate organic and inorganic contaminants are shown in Table 3-6.

With the exception of trace concentrations of toluene in the groundwater sample, the deep (200-foot) aquifer and the associated soil samples were uncontaminated with any other organic compounds. Inorganic contaminants are present in detectable concentrations in the deep soil samples, but only antimony (Sb), arsenic (As) and selenium (Se) were observed in the groundwater sample. The inorganic compounds (particularly arsenic and selenium) are present only at low concentrations (As-.05, Se-.26) within primary drinking water standards and present no public health or environmental threat. The presence of arsenic at 12.0 mg/kg in the soil samples may indicate a rather high natural background of this toxic material in the local clay substrata.

3.8 PRODUCTION WELL SAMPLES

Selected production wells located within close proximity to the site were sampled to determine the extent of any external migration of contaminants. Production well depths ranged from 300 to 500 feet below ground surface. Sampled production wells, labeled PW-01, 02, and 03 on Figure 3-1, proved to be uncontaminated with any detectable organics. Inorganic concentrations in excess of primary drinking water standards were observed in PW-01 for lead (0.36 ppm), in PW-02 for both cadmium (0.04 ppm) and lead (0.35 ppm) and in PW-03 for lead (0.30 ppm). Table 3-7 provides contaminant analysis for the deep production well samples.

TABLE 3-6
DEEP GROUNDWATER SAMPLING ANALYTICAL RESULTS

Volatile Organics (all values reported as PPB, ug/l)

<u>Contaminant</u>	OW-06 (06)	SL-11 (Soil) (11)	SL-19 (Soil) (19)
Toluene	49	ND	ND

Refractory Organics

No Compounds detected.

Toxic Metals and Inorganics (all values reported as PPM mg/l or mg/kg wet weight)

<u>Contaminant</u>	OW-06	SL-11 (Soil)	SL-19 (Soil)
Antimony (Sb)	0.1	ND	ND
Arsenic (As)	0.05	12.0	12.0
Beryllium (Be)	ND	0.30	0.31
Cadmium (Cd)	ND	0.30	0.31
Chromium (Cr)	ND	17.0	2.4
Copper (Cu)	ND	06	4.0
Lead (Pb)	ND	5.7	7.5
Mercury (Hg)	ND	0.003	ND
Nickel (Ni)	ND	1.5	4.6
Selenium (Se)	0.260	ND	ND
Silver (Ag)	ND	ND	ND
Thallium (Tl)	ND	2.1	1.9
Zinc (Zn)	ND	3.1	7.3

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TABLE 3-7
DEEP GROUNDWATER SAMPLING ANALYTICAL RESULTS
(PRODUCTION WELLS)

Volatile Organics

No volatile organic compounds detected.

Refractory Organics

No refractory organic compounds detected.

Toxic Metals and Inorganics (all values reported as PPM, mg/l)

<u>Contaminant</u>	<u>PW-01</u>	<u>PW-02</u>	<u>PW-03</u>
Cadmium (Cd)	ND	0.04	ND
Lead (Pb)	0.35	0.35	0.30
Zinc (Zn)	0.58	0.52	0.28

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4.0 POTENTIAL IMPACTS, EXPOSURE OR CONTAMINANT RELEASE

A preliminary assessment of the available site characterization data summarized above can provide useful direction to the prediction of potential onsite and off-site impacts of possible contaminant exposure or release to other environments. Two principal hazard areas of potential health or environmental impacts can be identified from preliminary assessment of the data. These are the surface and near-surface contamination of the soil materials in the immediate vicinity of previously identified disposal areas, and the associated shallow groundwater contamination observed in the same general areas. Surface water impacts are probably not significant health or environmental concerns based upon preliminary findings and current conditions, use and location. Deep percolation and contamination of local groundwater aquifers used for domestic, industrial or municipal water supplies are also considered to be non-threatening to public health or the environment.

4.1 SURFACE AND NEAR-SURFACE CONTAMINATION

Residual contaminants from earlier wood preserving and coal tar distillation activities at this site are restricted mainly to surface and near-surface (10-foot depths, or less) contamination with both organic (polynuclear aromatic hydrocarbons) and inorganic (toxic metal) compounds in the immediate vicinity of previous disposal areas.

The potential impacts of the surface and near-surface soil contamination in these areas are as sources of continued shallow groundwater contamination, and as sources of contaminant release to local environments from future development or use of the site. The soil contaminants do not appear to be an imminent threat to health or the environment due to volatilization, direct contact, or surface runoff exposures under present conditions.

4.2 SHALLOW GROUNDWATER CONTAMINATION

The groundwater sampling program conducted by CDM indicated that the shallow water table conditions at the site and the shallow sand strata (strata III on Figure 2-3) are locally contaminated with both PAH and toxic metal compounds, as consistent with the surface soil contamination observed in and near the previous disposal areas. The aerial extent of present groundwater contamination is not yet known, however, due to the limited groundwater sampling carried out during the CDM contaminant survey.) It is possible, however, that the shallow groundwater contamination is extensive, even extending off-site. More comprehensive sampling of local groundwater conditions will be necessary to determine the extent and rate of migration of contaminants in the shallow groundwater in and near the site. It was not evident at the time of CDM's work that the contamination of the shallow groundwater in the vicinity of the South Cavalcade Site poses any imminent threat to public health or the environment. There are no known users of the shallow groundwater, no known surface exposures such as ponds or standing water, and no known present concerns with discharges from the shallow sand strata to local surface drainage.

It is very likely that the shallow groundwater is also contaminated by a variety of local urban and industrial sources. Contamination of the deeper aquifers in the area, which are known to be used for domestic, industrial or municipal water supplies, was not considered by CDM to be a significant threat to public health or the environment.

5.0 REFERENCE DOCUMENTS

1. U.S. EPA Region VI File Documents. Copies of relevant EPA file documents on the South Cavalcade Site have been provided to CDM.
2. Texas Department of Water Resources File Documents. Pertinent information on file with the TDWR in relation to state regulatory actions for the site are included in a comprehensive microfiche file made available to CDM by TDWR. Files include correspondence, telephone memos, site summary, report excerpt, TDWR site investigation report and other documentation.
3. Texas Natural Resources Information System. Physical site data, remote sensing data, and other relevant site characterization information is readily available to CDM from the TNRIS Austin, Texas facilities. An index of available aerial photographic coverage of the site has been secured from TNRIS and appropriate photos selected and ordered.
4. U.S. Geological Survey. Recent USGS 7.5⁰ quad. sheets for the site and immediately surrounding areas have been obtained by CDM.
5. City of Houston. Land use and storm/sanitary sewer maps of the area of the site have been obtained from the Houston Public Works Department.
6. CDM Report and Files. The report "Cavalcade Contaminant Survey" in three volumes, dated July 11, 1983, is on-hand at CDM's Austin office, along with original data base for the report.
7. McClelland Engineers Reports. The MEI report "Reconnaissance Geotechnical Study, Proposed Cavalcade Yard Site" No. 0882-0282, dated May 20, 1983 is on-hand at CDM's Austin office. Their follow-up report to Koppers Company Inc. dated May 8, 1984, has been requested but not yet received.

8. Koppers Company, Inc. Koppers Company correspondence with TDWR and a copy of the report "Proposed Work Plan, Remedial Investigation/ Feasibility Study Koppers Company Inc. Former Cavalcade Plan Site, Houston, Texas" dated December 13, 1984, are on-hand at CDM Austin.

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APPENDIX II

SOP FOR DECONTAMINATION PROCEDURES

001547

Title: Decontamination **STANDARD OPERATING PROCEDURE**

Page 4 of 4

Date: 1st Qtr 1
Number: 7600
Revision: 1

1.0 General Applicability

This SOP describes the methods to be used for the decontaminization of all field equipment which becomes potentially contaminated during a sample collection task. The equipment may include split spoons, bailers, trowels, shovels, hand augers, or any other type of equipment used during field activities.

Decontamination is performed as a quality assurance measure and a safety precaution. It prevents cross-contamination between samples and also helps to maintain a clean working environment for the safety of all field personnel involved, including the environment.

Decontamination is mainly achieved by rinsing with liquids which include: soap and/or detergent solutions, tap water, deionized water, and methanol. Equipment will be allowed to air dry after being cleaned or may be wiped dry with chemical free cloths or paper towels if immediate re-use is needed.

The frequency of equipment use, dictates that most decontamination be accomplished at each sampling site between collection points. Waste products produced by the decontamination procedures such as waste liquids, solids, rags, gloves, etc. will be collected and disposed of properly based on the nature of contamination. All cleaning materials and wastes should be stored in a central location so as to maintain control over the quantity of materials used and/or produced throughout the study.

2.0 Responsibilities

It is the primary responsibility of the site operations manager to assure that the proper decontamination procedures are followed and that all waste materials produced by decontamination are properly stored and disposed of.

It is the responsibility of the project safety officer to draft and enforce safety measures which provide the best protection for all persons involved directly with sampling and/or decontamination.

It is the responsibility of any subcontractors (i.e., drilling contractors) to follow the proper, designated decontamination procedures that are stated in their contracts and outlined in the Project Health and Safety Plan.

It is the responsibility of all personnel involved with sample collection or decontamination to maintain a clean working environment and to ensure that any contaminants are not negligently introduced to the environment.

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ENVIRONMENTAL RESEARCH & TECHNOLOGY, INC. 696 VIRGINIA ROAD, CONCORD, MASSACHUSETTS 01732

1284b (12/78)

STANDARD OPERATING PROCEDURE

Title: **Decontamination**

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Date: 1st Qtr
Number: 760
Revision: 1

3.0 Supporting Materials

- cleaning liquids: soap and/or detergent solutions, tap water, deionized water, methanol
- personal safety gear (defined in Project Health and Safety Plan)
- chemical-free paper towels
- disposable gloves
- waste storage containers: drums, boxes, plastic bags
- cleaning containers: plastic buckets, galvanized steel pans
- cleaning brushes

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4.0 Methods or Protocol for Decontamination

4.1 General Procedures

- 4.1.1 The extent of known contamination will determine to what extent the equipment needs to be decontaminated. If the extent of contamination cannot be readily determined, cleaning should be done according to the assumption that the equipment is highly contaminated until enough data are available to allow assessment of the actual level of contamination.
- 4.1.2 Adequate supplies of all materials must be kept on hand. This includes all rinsing liquids and other materials listed in Section 3.0.
- 4.1.3 The standard procedures listed in the following section can be considered the procedure for full field decontamination. If different or more elaborate procedures are required for a specific project, they will be spelled out in the project work plan. Such variations in decontamination may include following all, just part, or an expanded scope of the decontamination procedure stated herein

4.2 Standard Procedures

- 4.2.1 Remove any solid particles from the equipment or material by brushing and then rinsing with available tap water. This initial step is performed to remove gross contamination.

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Title: Decontamination **STANDARD OPERATING PROCEDURE**

Page 3f 4

Date: 1st Qtr 1
Number: 7600
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- 4.2.2 Wash equipment sampler with the soap or detergent solution.
- 4.2.3 Rinse with tap water
- 4.2.4 Rinse with deionized water
- 4.2.5 Rinse with methanol
- 4.2.6 Repeat entire procedure or any parts of the procedure if necessary
- 4.2.7 Allow the equipment or material to air dry before re-using
- 4.2.8 Dispose of any soiled materials in the designated disposal container

5.0 Specific Decontamination Procedures

5.1 Submersible Pump

5.1.1 Applicability

This procedure will be used to decontaminate submersible pumps between ground-water sample collection points and at the end of each day of use.

5.1.1 Materials

- o plastic-nalgene upright cylinder
- o 5-10 gallon plastic water storage containers
- o methanol and dispenser bottle
- o deionized water and dispenser bottle
- o chemical free paper towels

5.1.3.1 During decontamination the submersible pump will be placed on a clean surface or held away from ground.

5.1.3.2 When removing the submersible pump from each well the power cord and discharge line will be wiped dry using chemical-free disposable towels.

5.1.3.3 Clean the upright plastic-nalgene cylinder with first a methanol and then a deionized water rinse, wiping the free liquids after each.

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1284b (12/78)

Title: **Decontamination**

STANDARD OPERATING PROCEDURE

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Date: 1st Qtr '76
Number: 760
Revision: 1

- 5.1.3.4 Reverse pump backwashing all removable residual water present in the pump tubing. The pump should be shut off as soon as intermittent flow is observed from the reverse discharge.
- 5.1.3.5 Rinse the stainless steel submersible down hole pump section with a liberal application of methanol and wipe dry.
- 5.1.3.6 Place the submersible pump section upright in the cylinder and fill the cylinder with tap water, adding 50-100 ml of methanol for every one liter of water.
- 5.1.3.7 Activate the pump in the forward mode withdrawing water from the cylinder.
- 5.1.3.8 Continue pumping until the water in the cylinder is pumped down and air is drawn through the pump. At this time air pockets will be observed in the discharge line. Shut off the pump immediately.
- 5.1.3.9 Remove the pump from the cylinder and place the pump in the reverse mode allowing that all removable water be discharged on to the ground surface as discussed in Step .
- 5.1.3.10 Using the water remaining in the cylinder, rinse the sealed portion of the power chord and discharge tube by pouring the water carefully over the coiled lines.
- 5.1.3.11 When reaching the next monitoring well place the pump in the well casing and wipe dry both the power and discharge lines with a clean paper towel as the pump is lowered.

5.1.4 Quality Assurance

To assure that decontamination is complete, field blank samples shall be collected using the cleaned submersible pump. These field blanks will be subsequently analyzed for the parameters of interest with respect to the ground water.

The procedure for collecting the field blanks will comprise using the pump to withdraw the tap water used for decontamination, from the plastic cylinder to sample containers. This field blank sample collection procedure shall only be performed after the materials to be used have been decontaminated.

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APPENDIX III

OCCUPATIONAL HEALTH DATA ON CONTAMINANTS OF CONCERN

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Occupational Health Guideline for Coal Tar Pitch Volatiles

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

Anthracene

- Formula: $C_{14}H_{10}$
- Synonyms: None
- Appearance and odor: Pale green solid with a faint aromatic odor.

Phenanthrene

- Formula: $C_{14}H_{10}$
- Synonyms: None
- Appearance and odor: Colorless solid with a faint aromatic odor.

Pyrene

- Formula: $C_{16}H_{10}$
- Synonyms: None
- Appearance: Bright yellow solid

Carbazole

- Formula: $C_{12}H_9N$
- Synonyms: None
- Appearance and odor: Colorless solid with a faint aromatic odor.

Benzo(a)pyrene

- Formula: $C_{20}H_{12}$
- Synonyms: BaP, 3,4-benzopyrene

- Appearance and odor: Colorless solid with a faint aromatic odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for coal tar pitch volatiles is 0.2 milligram of coal tar pitch volatiles per cubic meter of air (mg/m^3) averaged over an eight-hour work shift. NIOSH has recommended that the permissible exposure limit for coal tar products be reduced to 0.1 mg/m^3 (cyclohexane-extractable fraction) averaged over a work shift of up to 10 hours per day, 40 hours per week, and that coal tar products be regulated as occupational carcinogens. The NIOSH Criteria Document for Coal Tar Products and NIOSH Criteria Document for Coke Oven Emissions should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

• Routes of exposure

Coal tar pitch volatiles can affect the body if they are inhaled or if they come in contact with the eyes or skin.

• Effects of overexposure

Repeated exposure to coal tar pitch volatiles has been associated with an increased risk of developing bronchitis and cancer of the lungs, skin, bladder, and kidneys. Pregnant women may be especially susceptible to exposure effects associated with coal tar pitch volatiles. Repeated exposure to these materials may also cause sunlight to have a more severe effect on a person's skin. In addition, this type of exposure may cause an allergic skin rash.

• Reporting signs and symptoms

A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to coal tar pitch volatiles.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to coal tar pitch volatiles at potentially hazardous levels:

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the oral cavity, respiratory tract, bladder, and kidneys should be stressed. The skin should be examined for evidence of chronic disorders, for premalignant and malignant lesions, and evidence of hyperpigmentation or photosensitivity.

—Urinalysis: Coal tar pitch volatiles are associated with an excess of kidney and bladder cancer. A urinalysis should be obtained to include at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment, as well as a test for red blood cells.

—Urinary cytology: Coal tar pitch volatiles are associated with an excess of kidney and bladder cancer. Employees having 5 or more years of exposure or who are 45 years of age or older should have a urinary cytology examination.

—Sputum cytology: Coal tar pitch volatiles are associated with an excess of lung cancer. Employees having 10 or more years of exposure or who are 45 years of age or older should have a sputum cytology examination.

—14" x 17" chest roentgenogram: Coal tar pitch volatiles are associated with an excess of lung cancer. Surveillance of the lungs is indicated.

—FVC and FEV (1 sec): Coal tar pitch volatiles are reported to cause an excess of bronchitis. Periodic surveillance is indicated.

—A complete blood count: Due to the possibility of benzene exposure associated with coal tar pitch volatiles, a complete blood count is considered necessary to search for leukemia and aplastic anemia.

—Skin disease: Coal tar pitch volatiles are defatting agents and can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of these agents.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis, and semi-annually for employees 45 years of age or older or with 10 or more years' exposure to coal tar pitch volatiles.

• Summary of toxicology

Coal tar pitch volatiles (CTPV) are products of the destructive distillation of bituminous coal and contain polynuclear aromatic hydrocarbons (PNA's). These hydrocarbons sublime readily, thereby increasing the amounts of carcinogenic compounds in working areas. Epidemiologic evidence suggests that workers intimately exposed to the products of combustion or distillation of bituminous coal are at increased risk of cancer at many sites. These include cancer of the respiratory tract, kidney, bladder, and skin. In a study of coke oven workers, the level of exposure to CTPV and the length of time exposed were related to the development of cancer. Coke oven workers with the highest risk of cancer were those employed exclusively at topside jobs for 5 or more years, for whom the increased risk of

dying from lung cancer was 10-fold; all coke oven workers had a 7-1/2-fold increase in risk of dying from kidney cancer. Although the causative agent or agents of the cancer in coke oven workers is unidentified, it is suspected that several PNA's in the CTPV generated during the coking process are involved. Certain industrial populations exposed to coal tar products have a demonstrated risk of skin cancer. Substances containing PNA's which may produce skin cancer also produce contact dermatitis; examples are coal tar, pitch, and cutting oils. Although allergic dermatitis is readily induced by PNA's in guinea pigs, it is only rarely reported in humans from occupational contact with PNA's; these have resulted largely from the therapeutic use of coal tar preparations. Components of pitch and coal tar produce cutaneous photosensitization; skin eruptions are usually limited to areas exposed to the sun or ultraviolet light. Most of the phototoxic agents will induce hypermelanosis of the skin; if chronic photodermatitis is severe and prolonged, leukoderma may occur. Some oils containing PNA's have been associated with changes of follicular and sebaceous glands which commonly take the form of acne. There is evidence that exposures to emissions at coke ovens and gas retorts may be associated with an increased occurrence of chronic bronchitis. Coal tar pitch volatiles may be associated with benzene, an agent suspected of causing leukemia and known to cause aplastic anemia.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data—Anthracene

1. Molecular weight: 178.2
2. Boiling point (760 mm Hg): 340 C (644 F)
3. Specific gravity (water = 1): 1.24
4. Vapor density (air = 1 at boiling point of anthracene): 6.15
5. Melting point: 217 C (423 F)
6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble

8. Evaporation rate (butyl acetate = 1): Not applicable

• Physical data—Phenanthrene

1. Molecular weight: 178.2
2. Boiling point (760 mm Hg): 340 C (644 F)
3. Specific gravity (water = 1): 1.18
4. Vapor density (air = 1 at boiling point of phenanthrene): 6.15
5. Melting point: 100.5 C (213 F)
6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble

8. Evaporation rate (butyl acetate = 1): Not applicable

• Physical data—Pyrene

1. Molecular weight: 202.3
2. Boiling point (760 mm Hg): Greater than 360 C (greater than 680 F)

3. Specific gravity (water = 1): 1.28
4. Vapor density (air = 1 at boiling point of pyrene): 6.9
5. Melting point: 150.4 C (303 F)
6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Physical data—Carbazole**

1. Molecular weight: 167.2
2. Boiling point (760 mm Hg): 355 C (671 F)
3. Specific gravity (water = 1): Greater than 1
4. Vapor density (air = 1 at boiling point of carbazole): 5.8
5. Melting point: 246 C (475 F)
6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Physical data—Benzo(a)pyrene**

1. Molecular weight: 252.3
2. Boiling point (760 mm Hg): Greater than 360 C (greater than 680 F)
3. Specific gravity (water = 1): Greater than 1
4. Vapor density (air = 1 at boiling point of benzo(a)pyrene): 8.7
5. Melting point: 179 C (354 F)
6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

• **Reactivity**

1. Conditions contributing to instability: None hazardous
2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
3. Hazardous decomposition products: None
4. Special precautions: None

• **Flammability**

1. Flash point: Anthracene: 121 C (250 F) (closed cup); Others: Data not available
2. Autoignition temperature: Anthracene: 540 C (1004 F); Others: Data not available
3. Flammable limits in air, % by volume: Anthracene: Lower: 0.6; Others: Data not available
4. Extinguishant: Foam, dry chemical, and carbon dioxide

• **Warning properties**

Grant states that "coal tar and its various crude fractions appear principally to cause reddening and squamous eczema of the lid margins, with only small erosions of the corneal epithelium and superficial changes in the stroma, which disappear in a month following exposure. Chronic exposure of workmen to tar fumes and dust has been reported to cause conjunctivitis and discoloration of the cornea in the palpebral fissure,

either near the limbus or, in extreme cases, across the whole cornea. Occasionally, epithelioma of the lid margin has been attributed to contact with coal tar."

MONITORING AND MEASUREMENT PROCEDURES

• **General**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• **Method**

Coal tar products may be sampled by collection on a glass fiber filter with subsequent ultrasonic extraction and weighing. An analytical method for coal tar pitch volatiles is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 1, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00267-3).

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent skin contact with condensed coal tar pitch volatiles, where skin contact may occur.

• If employees' clothing may have become contaminated with coal tar pitch volatiles, employees should change into uncontaminated clothing before leaving the work premises.

• Clothing contaminated with coal tar pitch volatiles

should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of coal tar pitch volatiles from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the coal tar pitch volatiles, the person performing the operation should be informed of coal tar pitch volatiles's hazardous properties.

- Employees should be provided with and required to use splash-proof safety goggles where condensed coal tar pitch volatiles may contact the eyes.

SANITATION

- Workers subject to skin contact with coal tar pitch volatiles should wash with soap or mild detergent and water any areas of the body which may have contacted coal tar pitch volatiles at the end of each work day.
- Employees who handle coal tar pitch volatiles should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.
- Areas in which exposure to coal tar pitch volatiles may occur should be identified by signs or other appropriate means, and access to these areas should be limited to authorized persons.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to coal tar pitch volatiles may occur and control methods which may be effective in each case:

Operation	Controls
Liberation from extraction and packaging from coal tar fraction of coking	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use as a binding agent in manufacture of coal briquettes used for fuel; use as a dielectric in the manufacture of battery electrodes, electric-arc furnace electrodes, and electrodes for alumina reduction	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in manufacture of roofing felts and papers and roofing	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment

Operation

Use for protective coatings for pipes for underground conduits and drainage; use as a coating on concrete as waterproofing and corrosion-resistant material; use in road paving and sealing

Use in manufacture and repair of refractory brick; use in production of foundry cores; use in manufacture of carbon ceramic items

Controls

Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment

Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If condensed coal tar pitch volatiles get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with these chemicals.

• Skin Exposure

If condensed coal tar pitch volatiles get on the skin, wash the contaminated skin using soap or mild detergent and water. Be sure to wash the hands before eating or smoking and to wash thoroughly at the close of work.

• Breathing

If a person breathes in large amounts of coal tar pitch volatiles, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of releases until cleanup has been completed.
- If coal tar pitch volatiles are released in hazardous concentrations, the following steps should be taken:
 1. Ventilate area of spill.

2. Collect released material in the most convenient and safe manner for reclamation or for disposal in sealed containers in a secured sanitary landfill.

- Waste disposal method:

Coal tar pitch volatiles may be disposed of in sealed containers in a secured sanitary landfill.

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RESPIRATORY PROTECTION FOR COAL TAR PITCH VOLATILES

Condition	Minimum Respiratory Protection* Required Above 0.2 mg/m ³
Particulate and Vapor Concentration	
2 mg/m ³ or less	<p>A chemical cartridge respirator with an organic vapor cartridge(s) and with a fume or high-efficiency filter.</p> <p>Any supplied-air respirator.</p> <p>Any self-contained breathing apparatus.</p>
10 mg/m ³ or less	<p>A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s) and with a fume or high-efficiency filter.</p> <p>A gas mask with a chin-style or a front- or back-mounted organic vapor canister and with a full facepiece and a fume or high-efficiency filter.</p> <p>Any supplied-air respirator with a full facepiece, helmet, or hood.</p> <p>Any self-contained breathing apparatus with a full facepiece.</p>
200 mg/m ³ or less	<p>A Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode.</p> <p>A powered air-purifying respirator with an organic vapor cartridge and a high-efficiency particulate filter.</p>
400 mg/m ³ or less	<p>A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.</p>
Greater than 400 mg/m ³ or entry and escape from unknown concentrations	<p>Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.</p> <p>A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.</p>
Fire Fighting	<p>Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.</p>
Escape	<p>Any gas mask providing protection against organic vapors and particulates, including pesticide respirators which meet the requirements of this class.</p> <p>Any escape self-contained breathing apparatus.</p>

*Only NIOSH-approved or MSHA-approved equipment should be used.

Spray workers exposed at 0.5% Dursban emulsion in field trials for malaria control on premises showed a measurable decrease in plasma and red cell cholinesterase levels.⁽¹⁰⁾ In this study, 5 of 7 sprayers showed more than 50 per cent reduction in cholinesterase within two weeks after the spraying program began. In another study,⁽⁶⁾ human volunteers were exposed to thermal aerosols containing Dursban insecticide for one period. Exposures of 3 to 8 minutes at concentrations of about $0.8 \mu\text{m}/\text{m}^3$ in air produced no significant alteration of cholinesterase levels. This concentration resulted from the recommended application rate in thermal fogging.

Available studies indicate that Dursban is rapidly metabolized in the animal body.⁽⁸⁾

There was evidence of teratologic or reproductive effects in male and female rats fed 1.0 mg/kg per day during a three-generation reproduction and fertility study.⁽¹¹⁾

A TLV of 0.2 and a STEL of $0.6 \text{ mg}/\text{m}^3$ are recommended to prevent any measurable decrease in plasma cholinesterase activities and provides a very wide margin of safety in preventing cholinergic symptoms or organic injury.

CHROMIUM

Cr

Metal and Inorganic Compounds, as Cr

TLV, $0.5 \text{ mg}/\text{m}^3$ — Metal

$0.5 \text{ mg}/\text{m}^3$ — Cr II Compounds

$0.5 \text{ mg}/\text{m}^3$ — Cr III Compounds

$0.05 \text{ mg}/\text{m}^3$ — Water Soluble Cr VI Compounds

$0.05 \text{ mg}/\text{m}^3$, Appendix A1a — Recognized Carcinogen
— Certain Water Insoluble Cr VI Compounds

Chromium is a metallic element, atomic number 24, atomic weight 51.996, in Group VIB of the periodic table. It is a steel-gray, lustrous metal, with a specific gravity of 7.20. The melting point is 1900°C and boils at 2642°C . The metal reacts with dilute hydrochloric acid and sulfuric acid, but not with nitric acid.

Chromium metal was first isolated in 1798. The chief uses of chromium and chromium compounds are in stainless and alloy steels, refractory products, tanning agents for leather, pigments, electroplating, catalyst and in corrosion resistant products. Chromium is obtained from chromite ores ($\text{FeO} \cdot \text{Cr}_2\text{O}_3$). Relatively large deposits of chromite ore were found near Baltimore in the United States but no mining has taken place there since 1961.

Chromium can have a valence of 2, 3 or 6, and a wide range of chromium alloys and inorganic chromium compounds are encountered in the workplace. These chromium compounds vary greatly in their toxic and carcinogenic effects. For this reason it is necessary to divide chromium and its inorganic compounds into a number of groupings — each with its specific TLV based on available toxicological and epidemiological evidence. These groupings are:

1. Chromium metals and alloys

This grouping includes chromium metal, stainless steels and other chromium-containing alloys.

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2. Divalent chromium compounds (Cr^{2+}) (Chromous compounds)

This grouping includes chromous chloride (CrCl_2) and chromous sulfate (CrSO_4).

3. Trivalent chromium compounds (Cr^{3+}) (Chromic compounds)

This grouping includes chromic oxide (Cr_2O_3), chromic sulfate ($\text{Cr}_2(\text{SO}_4)_3$), chromic chloride (CrCl_3), chromic potassium sulfate ($\text{KCr}(\text{SO}_4)_2$) and chromite ore ($\text{FeO} \cdot \text{Cr}_2\text{O}_3$).

4. Hexavalent chromium compounds (Cr^{6+})

This grouping includes chromium trioxide (CrO_3) — the anhydride of chromic acid — chromates (e.g., Na_2CrO_4), dichromates (e.g., $\text{Na}_2\text{Cr}_2\text{O}_7$) and polychromates. Certain hexavalent chromium compounds have been demonstrated to be carcinogenic on the basis of epidemiological investigations on workers and experimental studies in animals. In general, these compounds tend to be of low solubility in water and thus may be subdivided into two subgroups:

(a) Water soluble hexavalent chromium compounds

These include chromic acid and its anhydride, and the monochromates and dichromates of sodium, potassium, ammonium, lithium, cesium and rubidium.

(b) Water insoluble hexavalent chromium compounds

These include zinc chromate, calcium chromate, lead chromate, barium chromate, strontium chromate and sintered chromium trioxide.

Hexavalent Chromium

The first cases of occupational health effects from hexavalent chromium were reported in 1827⁽¹⁾ by Cumin, who observed cases of skin ulceration and dermatitis in dye workers handling potassium dichromate. Mackenzie⁽²⁾ in

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1884 reported that perforation of the nasal septum occurred in workers exposed to potassium bichromate. Da-Costa *et al*⁽⁴⁾ in 1916 described chrome ulcers in tanners and dryers. Parkhurst⁽⁵⁾ in 1925 reported chrome dermatitis in blueprint workers exposed to potassium dichromate. Bloomfield and Blum⁽⁶⁾ reported on their study of electroplaters exposed to acidic mist of hexavalent chromium compounds. They noted that 20 or 23 workers examined showed evidence of perforated or ulcerated nasal septa and skin ulcers (*chrome holes*). The Factory Inspectorate in Great Britain⁽⁷⁾ reported in 1930 on the results of medical examinations of 223 persons engaged in chromium plating; 42.6% had dermatitis or skin ulcers and 52% had perforated or ulcerated nasal septa.

The occupational health literature affords abundant evidence that hexavalent chromium compounds may cause irritant and allergic contact dermatitis, skin ulcers, and nasal irritation varying from rhinitis to perforation of the nasal septum. Dermatitis from exposure to soluble hexavalent chromium has been reported in lithographers^(8,9) diesel repair shop workers⁽¹⁰⁾ and leather workers.⁽¹¹⁾ Soluble chromates in cement have been stated to be the cause of cement dermatitis in some workers.⁽¹²⁾

Attempts have been made to correlate the airborne levels of hexavalent chromium with irritation of the nasal mucosa. In the study by Bloomfield and Blum,⁽⁶⁾ electroplaters were exposed to estimated exposures ranging from 0.06 to 2.8 mg/m³ (as Cr⁶⁺). Levels of Cr⁶⁺ in the form of chromium trioxide, were capable of giving rise to nasal irritation at concentrations as low as 0.06 mg/m³. It is difficult to rule out the importance of personal hygiene in the production of nasal symptoms from direct transfer of chromium (Cr⁶⁺) to the nasal mucosa. Nasal irritation is produced from exposure to soluble chromate and bichromate salts as well as to chromic acid mist.^(12,13) The study by the U.S. Public Health Service⁽¹⁴⁾ noted that the mean concentration of water-soluble chromium in plants where nasal irritation was encountered was 0.068 mg/m³ as Cr⁶⁺.

Epidemiological studies showing an increased incidence of lung cancer among workers involved in the manufacture of chrome pigments have been reported from Germany,⁽¹⁵⁾ Norway⁽¹⁶⁾ and United States.⁽¹⁷⁾ Machle and Gregorius⁽¹⁸⁾ first reported increased incidence of lung cancer in the United States chromate industry. Baetjer⁽¹⁹⁾ carried out a case control study and confirmed the increased risk of lung cancer among the U.S. chromate workers. Mancuso and Hueper⁽¹⁹⁾ attempted to estimate the airborne exposures to chromium in those who developed lung cancer. They found that these workers were exposed to 0.01 to 0.15 mg/m³ of water soluble chromium and 0.1 to 0.58 mg/m³ of water insoluble chromium. The insoluble fraction was denoted as Cr³⁺ and the soluble as Cr⁶⁺ but it is impossible to assign Cr⁶⁺ or Cr³⁺ exclusively to either fraction.

The chromate workers in the preceding studies were exposed to various Cr³⁺ and Cr⁶⁺ compounds as well as to other substances. In general, the evidence does not suggest that chromite ore, a water insoluble Cr³⁺ substance, is a carcinogen. While the evidence is incomplete it does appear that certain Cr⁶⁺ compounds, mainly water insoluble, were involved in increased risk of lung cancer. The experimental data from animals supports the view that water insoluble Cr⁶⁺ compounds, e.g., chromic and zinc chro-

mates, are carcinogenic, whereas the soluble forms are not.⁽²⁰⁾ Royle,⁽²¹⁾ however, has reported an increase in lung and other cancers in chrome platers in England.

Hexavalent chromium compounds have been said to also cause kidney damage in workers^(22,23) where absorption through damaged skin has occurred.

The TLVs for hexavalent chromium compounds are recommended as follows:

- (a) Water soluble hexavalent chromium compounds (see examples noted above). A TLV of 0.05 mg/m³ as water soluble Cr⁶⁺ is considered adequate to protect against irritation of the respiratory tract and possible kidney and liver damage. NIOSH in the criteria document on chromic acid⁽²⁴⁾ recommended that occupational exposures be controlled to prevent exposures above 0.05 mg/m³ TWA. In a later criteria document on hexavalent chromium⁽²⁵⁾ NIOSH recommended a permissible exposure limit of 0.025 mg/m³.
- (b) Certain water insoluble hexavalent chromium compounds (see examples noted above). A TLV of 0.05 mg/m³ as water insoluble Cr⁶⁺ and insertion in appendix A1a is recommended. There is, unfortunately, little previous environmental data from those exposures associated with increased respiratory cancer risk. With the data available, however, this TLV provides an adequate margin of safety. NIOSH recommended a permissible exposure limit of 0.001 mg/m³ for certain insoluble hexavalent chromium compounds.⁽²⁵⁾
- (c) Mixed exposure to soluble and insoluble hexavalent chromium compounds. A TLV of 0.05 mg/m³ as Cr⁶⁺ is recommended.
- (d) Chromite ore processing
Chromate pigment manufacture
It may be advisable to list these process TLVs both as 0.05 mg/m³ as Cr and include them in appendix A1a. This TLV will serve to draw attention to those processes where increased risk of cancer has been associated with chromium compounds.

Chromium Metal

Divalent chromium compounds

(see examples listed earlier)

Trivalent chromium compounds

(see examples listed earlier)

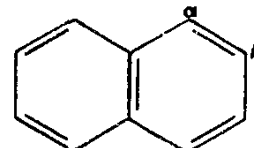
Early studies indicated that trivalent chromium and divalent chromium compounds have a low order of toxicity.⁽²⁶⁾ Dermatitis has been reported in workers handling trivalent chromium compounds.^(27,28)

Chest X-rays carried out in workers exposed to chromite dust have been reported to show "exaggerated pulmonary markings"⁽²⁹⁾ and Princiet *et al*⁽³⁰⁾ have reported pulmonary disease in workers exposed to ferrochrome alloys with chromium levels in air of 0.27 mg/m³ reported. Other dusts and fumes were present, however, in this plant. Exposure to chromium metal does not give rise to pulmonary fibrosis or pneumoconiosis.

NAPHTHA

See, RUBBER SOLVENT

NAPHTHALENE

 $C_{10}H_8$ TLV, 10 ppm ($\approx 50 \text{ mg/m}^3$)STEL, 15 ppm ($\approx 75 \text{ mg/m}^3$)

Naphthalene occurs commonly as white, crystalline flakes which have a strong coal tar odor. It has a molecular weight of 128.16 and a specific gravity of 1.145. It melts at 80.2°C , boils at 217.96°C and has a vapor pressure at 25°C of approximately 0.087 mm Hg. The open cup flash point is 176°F and closed cup is 190°F . Insoluble in water, it dissolves in most organic solvents.

Crystalline naphthalene finds household use as a moth repellent, scientific use in scintillation counters. It is an important raw material for the manufacture of phthalic anhydride, naphthol, hydrogenated naphthalenes and halogenated naphthalenes; it or its derivatives are employed in dyes, explosives, lubricants, tanning agents and emulsion breakers.

According to Flury and Zernik⁽¹⁾ and Patty,⁽²⁾ the inhalation of naphthalene vapor may cause headache, loss of appetite and nausea. Optical neuritis and injuries to the cornea and, in addition, kidney damage have also been reported. Ghetti and Mariani⁽³⁾ reported opacities of the lens in 8 of 21 workers who had been exposed to naphthalene for about five years. Ingestion of naphthalene in relatively large amounts has reportedly caused severe hemolytic anemia and hemoglobinuria.⁽⁴⁾ A hypersusceptibility, probably genetically based, is recognized.⁽⁵⁾

The oral LD_{50} for rats is 1760 mg/kg.⁽⁶⁾ It was used as an anthelmintic for many years at dose levels, for adults, of 0.1 to 0.5 gram three times a day,⁽⁷⁾ several times higher than the lowest reported lethal dose for man of 50 mg/kg.⁽⁶⁾ An incident in which blankets containing naphthalene caused acute hemolytic effects in infants, in some cases fatal, has been described.⁽⁸⁾

Patty suggested 25 ppm as a tentative limit for naphthalene vapor in air. He noted that this corresponds to a saturation pressure of approximately 25% at 25°C . This value has been used at the Los Alamos Laboratories, according to

Hyatt and Milligan.⁽⁹⁾ Robbins,⁽¹⁰⁾ however, reported that concentrations in excess of about 15 ppm resulted in noticeable irritation of the eyes.

Gerarde⁽¹¹⁾ also suggested 25 ppm as a tentative limit, noting that it represents 25% of the concentration of naphthalene vapor in air saturated at 25°C .

In view of the fact that irritation is experienced at 15 ppm and that continued exposure may result in fairly serious eye effects, a limit lower than 25 ppm would seem in order. The value of 10 ppm TLV and 15 ppm STEL are recommended to prevent ocular effects, but possibly not blood changes in hypersusceptibles.

Other recommendations: West Germany, 10 ppm East Germany and USSR, 4 ppm.

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COAL TAR PITCH VOLATILES

as, Benzene Soluble Fraction

TLV, 0.2 mg/m³, Appendix A1a — Recognized Carcinogen

The pitch of coal tar is the black or dark brown amorphous residue that remains after the redistillation process. The volatiles contain a large quantity of lower molecular weight polycyclic hydrocarbons.⁽¹⁻³⁾ As these hydrocarbons (naphthalene, fluorene, anthracene, acridine, phenanthrene) sublime into the air and there is an increase of benzo(a)pyrene (BaP or 3,4-benzopyrene) and other higher weight polycyclic hydrocarbons in the tar and in the fumes. Polycyclic hydrocarbons, known to be carcinogenic, are of this large molecular type.

Coal tar is used as a base for coatings and paints, for roofing and paving, and as a binder for carbon electrodes.

Doll⁽⁴⁾ found that deaths from cancer of the lungs and pleura of retired gas-workers is approximately two times the expected rate.

Coal tar pitch polluted air is characterized by large amounts of phenanthrene, anthracene, pyrene and carbazole. Coal tar pitch contains approximately 10% polycyclic hydrocarbons, and three different samples analyzed by Sawicki et al⁽¹⁾ gave a concentration of 1.4% BaP alone.

Samples collected in urban and nonurban sites^(5,6) contained a range of 2.4-410 µg BaP/g of particulate (38-2600 µg BaP/g of benzene fraction or 0.11-61 µg/1000 m³ of air) in the former locations and 0.15-51 µg BaP/g of particulate (9.3-730 µg BaP/g of benzene soluble fraction or 0.01-1.9 µg BaP/1000 m³ of air) in the latter⁽³⁾ during a three-month period, January through March.

Falk et al⁽⁷⁻¹⁰⁾ pointed out that the amount of BaP in the air was greater than one would expect on the basis of comparative quantitative emissions of other hydrocarbons. The composition of the hydrocarbons varies with time and distance, suggesting differences in stability of the compounds. The authors conclude that chrysene, 1,12-benzoperylene, coronene, and BaP are stable, and phenanthrene, an "unidentified hydrocarbon" and anthranthrene are most readily destroyed, usually within 48 hours. Intermediate stability is demonstrated by pyrene (58% recovery in 48 hours) and fluoranthrene (80% recovery in 48 hours).

Stability of polycyclic hydrocarbons was also studied by Commins and Lawther.⁽¹¹⁾ They point out that the temperature applied to sinter the filter used to collect the sample altered the apparent stability for BaP. They concluded that the filter should never be subjected to temperatures above 100° C; no loss of BaP was found after heating 100 µg BaP on a sintered disc in a sealed tube at 100° C for seven hours.

In further experiments, Kotin et al⁽⁸⁾ painted the interscapular area of C57 black mice three times weekly with benzene extracts of natural smog. First tumors appeared 465 days following the initial application.

Fairhall⁽¹²⁾ stated that fumes of dust from native asphalt do not present a substantial health hazard in comparison with coal tar fume or dust, citing the work of Hueper⁽¹³⁾ and Davies.⁽¹⁴⁾ Hueper⁽¹³⁾ also pointed out that, as a rule, a minimal time of exposure of one to five years is required to develop occupational cancer. Similarly, occupational can-

cers often develop many years after exposure to carcinogens has ceased. Simmers⁽¹⁶⁾ concluded that the degree of change noted in the lungs of rats breathing air contaminated with aromatic polycyclic hydrocarbons is dose-dependent.

In its criteria document for coal tar products, NIOSH cites papers dealing primarily with coke oven and aluminum potroom workers.⁽¹⁷⁾ A study of aluminum industry potroom workers⁽¹⁸⁾ showed an increase in lung cancer mortality. A paper on this industry in the Soviet Union associates such an increase with concentrations of tarry substances between 27 and 2130 mg/m³, while the BaP levels were between 0.6 and 56 µg/m³.⁽¹⁹⁾ High respiratory mortality among coke oven workers in Great Britain was reported.⁽²⁰⁾ Kidney as well as lung cancer was relatively prevalent among American coke-oven workers exposed 5 years or more.⁽²¹⁾

Animal studies indicating that lung and kidney tumors were caused by exposure to coal tar aerosols were also cited.

The occupational exposure standard recommended by NIOSH was 0.1 mg/m³ for the cyclohexane extractable fraction.⁽¹⁷⁾ A 1977 summary, however, gives 0.2 mg/m³ as the NIOSH recommendation for coal tar pitch volatiles.⁽²²⁾

In the absence of more definitive information on the identity of the components of coal tar pitch aerosols responsible for carcinogenic effects, a TLV based on the benzene (or other suitable solvent) soluble fraction appears to be the most practical compromise. If the concentration of aerosols from coal tar, on this basis, is maintained below 0.2 mg/m³, any increase in the incidence of lung and other tumors, due to occupational exposure, should be minimal.

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ZINC CHLORIDE



Fume

TLV, 1 mg/m³

STEL, 2 mg/m³

Zinc chloride may be in the form of a non-combustible, white powder or colorless crystals. Both are deliquescent and have a molecular weight of 136.29 and a specific gravity of 2.807 at 25° C. The fume of zinc chloride is white with an acrid odor. This compound boils at 732° C and melts at about 290° C. It is soluble in water, alcohol and ether.

The chloride is the common inorganic salt of zinc, and is used in soldering fluxes, galvanizing iron, as a wood preservative, in textiles, adhesives, dentrifices, deodorants, embalming fluids, and in organic synthesis and petroleum refining. Zinc chloride is the main ingredient of some screening smokes.

Exposure to zinc chloride fume can cause damage to the mucous membranes of the nasopharynx and respiratory tract. Exposed persons have experienced a pale gray cyanosis. Zinc chloride is caustic and can cause ulceration of exposed surfaces of the skin.⁽¹⁾ Inhalation may produce a severe pneumonitis resulting from irritation of the respiratory tract.⁽²⁾

Hunter⁽³⁾ reported 10 deaths and 25 cases of non-fatal injury among 70 persons in a tunnel when 79 smoke generators caught fire in a storage area. Most of the patients began to recover on the tenth day and were up and about six weeks after the incident. In two necropsies performed on the fatal cases, membranes lining the larynx, trachea and bronchi were red and edematous, with spots of necro-

sis. Milliken and associates⁽⁴⁾ reported a case of fatal, acute interstitial fibrosis from inhaling ZnCl₂ smoke from a smoke generator. In 18 days the patient developed advanced pulmonary fibrosis, acute cor pulmonale and right ventricular hypertrophy, and ultimately died from acute respiratory insufficiency.

Hardy⁽⁵⁾ comments that zinc chloride is caustic and because of the way it is used in industry causes trouble disproportionate to its harmful nature. She cites references suggesting that zinc compounds may have chronic effects. Ferry,⁽⁶⁾ in investigating a borderline condition, found that levels between 0.07 and 0.4 mg/m³ of zinc chloride fume for 30 minutes did not result in sensory effects, but was corrosive to metals.

To prevent respiratory irritation and other effects, a TLV of 1 mg/m³ and a STEL of 2 mg/m³ are recommended.

Although insoluble zinc compounds such as the oxide and stearate (q.v.) appear less hazardous, there are not enough data to categorize the relative hazards from other soluble zinc salts, such as the nitrate and sulfate.

The Swedish limit (1978) for ZnCl₂ is also 1 mg/m³.

References:

1. Sax, N.I.: *Dangerous Properties of Industrial Materials*, p 1268, Reinhold Pub. Corp., NY (1957).
2. Gafaler, W.M.: *Occupational Diseases*, Pub. Health Serv. Publ. #1097, U.S. Gov. Printing Office, Washington, DC (1964).
3. Hunter, D.: *The Diseases of Occupation*, pp. 367-377, Little, Brown & Co., Boston, MA (1955).
4. Milliken, J.A., Waugh, D., Kadish, M.E.: *Can. Med. Assoc. J.* 88:36 (1963).
5. Hamilton, A., Hardy, H.L.: *Industrial Toxicology*, 3rd ed., p 187, Publishing Sciences Group, Acton (1974).
6. Ferry, J.: Communication to TLV Committee (1966).

ZINC CHROMATES



TLV, 0.05 mg/m³, as Cr, Appendix A2 — Suspected Carcinogen

The basic zinc chromate is yellow in color and exists in prism form; molecular weight 181.36, specific gravity 3.40. ZnCr₂O₄ has a molecular weight of 233.36 and a specific gravity of 5.30 at 15° C, and its cubes are dark green to black in color. The dichromate is an orange powder with a molecular weight of 281.35. All are soluble in acids, but sparingly soluble in water.

Although finding some use as colors, they are primarily employed in priming paints for metals, for which they provide resistance against corrosion. The pigment zinc yellow is potassium zinc chromate.

Because of their very slight solubility in water, zinc chromate is considered more likely to produce cancer of

the respiratory passages, when inhaled, than are the water soluble chromates. While an increased incidence of lung cancer has reported among groups of pigment workers exposed to chromates,⁽¹⁾ including zinc chromate,⁽²⁾ a classification of suspected, rather than actual human carcinogen seems appropriate at this time.

The TLV of 0.05 mg Cr/m³, the same as that of lead chromate, is retained for the present. A review would be in order, however, if the limit for the insoluble chromates was reduced.

For additional information, see the documentation for chromium and its compounds in this book.

References:

1. Equitable Environmental Health, Inc.: *An Epidemiological Study of Workers in Lead Chromate Plants*, final report submitted to The Dry Color Manufacturers Assoc. (June 25, 1976).
2. Langard, S., Norseth, T.: *Brit. J. Ind. Med.* 32:62-65 (1975).

ZINC OXIDE

ZnO

Fume

TLV, 5 mg/m³

STEL, 10 mg/m³

Zinc, a metallic element with atomic number 30, atomic weight 65.38, is in Group IIB of the periodic table. It has a specific gravity of 7.14, a melting point of 419° C and a boiling point of 907° C. When heated in air to temperatures approaching its boiling point, it volatilizes and immediately oxidizes to make a white fume of zinc oxide. The oxide of zinc is a white or yellowish-white, non-flammable powder, which sublimates under normal pressure. The molecular weight is 81.38, specific gravity is 5.47 and melting point is 1975° C. It is insoluble in water, but dissolves readily in acids or alkalis.

The major uses of metallic zinc include galvanizing of iron and other metals, electroplating, and in dry cells and other electrical equipment. It is an important component of brass, bronze, die casting metal and other alloys. Zinc oxide itself is widely used in pigments, rubber, cosmetics and ointments, and electronic devices.

According to Fairhall,⁽¹⁾ the toxicity of zinc compounds by mouth is low. Metal fume fever (zinc chills, brass founder's ague, etc.) may result from the inhalation of zinc oxide fume. The symptoms include fever, chills, muscular pain, nausea and vomiting, however complete recovery occurs in 24 to 48 hours. The same effects are produced by the fumes of some other metals, and according to Turner and Thompson⁽²⁾ can also result from breathing finely divided zinc oxide dust.

Most authorities agree that metal fume fever itself is a relatively innocuous condition. It has been described as temporary and never serious,⁽³⁾ of brief duration and without after-effects,⁽⁴⁾ never fatal,⁽⁵⁾ without medical evidence of chronic effects⁽⁶⁾ and an annoyance.⁽⁷⁾ Hamilton⁽⁸⁾ stated that the weight of evidence was against the existence of chronic industrial zinc poisoning, although a number of reports to the contrary are in the older literature.

Drinker and Fairhall,⁽⁹⁾ however, considered that the symptoms described as chronic industrial zinc poisoning were due to contamination by other substances. Hegsted *et al*⁽⁷⁾ reviewed the literature of metal fume fever and injury from powders and dusts (of zinc) and concluded that there was evidence that severe exposure to zinc might give rise to gastritis, with vomiting, due to the swallowing of the dust of zinc compounds. Hamdi⁽¹⁰⁾ reported that workers in a brass foundry had more gastric symptoms than controls.

The medical studies of metal fume fever due to zinc contain little information of direct bearing on the threshold limit. Turner and Thompson⁽²⁾ described the effects of exposure of guinea pigs to zinc oxide fume. Exposures of an hour to concentration of ZnO given as 1000 to 2600 mg/m³ resulted in an initial drop in body temperature of 0.5 to 2° C, followed 6 to 18 hours later by a rise to 0.5 to 1° C above normal. Animals exposed at a concentration up to 2500 mg/m³ for three to four hours died during or immediately after exposure.

Drinker and co-workers⁽¹¹⁾ concluded that metal fume fever would not result from concentrations of zinc oxide below 15 mg/m³, and this concentration was the recommended threshold limit for a number of years. The more recent experience of several observers has been that concentrations of zinc fume rarely exceed 15 mg/m³ in non-ferrous foundries, but that, nevertheless, zinc chills frequently occur in such establishments⁽¹²⁻¹⁵⁾ and have been reported from concentrations below 5 mg/m³.^(16,17)

Hammond,⁽¹⁸⁾ however, reported that workers engaged in pouring molten zinc, and exposed to ZnO fumes in concentrations of 8 to 12 mg of zinc per cubic meter of air, were never recorded as suffering metal fume fever. Other men used oxy-acetylene torches to cut out zinc bound linings of stonecrushers, and were exposed for one to three hours at concentrations between 320 and 580 mg of zinc fumes per cubic meter of air. These workers experienced nausea on the job, and chills, shortness of breath and severe chest pains two to twelve hours later. The average period of disablement was four days. Some attacks were followed by pneumonia.

Pegues⁽¹⁹⁾ reported concentrations between 12 and 183 mg of ZnO/m³ in the welding of galvanized and zinc silicate coated steel. There were lesser exposures to iron and lead oxides. No mention is made of symptoms among the welders.

Vallee⁽²⁰⁾ gave the normal human intake of zinc in food as 10 to 15 mg per day, and the average urinary excretion as 0.3 to 0.4 mg per 24 hours. Hamdi⁽¹⁰⁾ reported 24-hour excretions of 0.4 to 0.6 mg among workers who suffered mild gastric symptoms (but not chills) attributed to zinc. Concentrations of 0.6 to 0.7 mg/liter have been found in the urines of workers exposed to zinc oxide fume in concentrations between 3 and 5 mg/m³.⁽²¹⁾

Beeckmans and Brown⁽²²⁾ reported that the inhalation toxicity of catalytically active zinc oxide dust was markedly increased by ultraviolet radiation.

In its criteria document for zinc oxide, NIOSH recommended retention of the 5 mg/m³ limit as a workplace environmental standard, and that the same value be used for zinc oxide dust.⁽²³⁾ While dismissing the reports of metal fume fever from concentrations of the order of 5 mg/m³ as unsupported by firm data, it considered that the possibility of chronic respiratory effects from either fume or dust could not be dismissed.

It is recommended that the TLV of 5 mg/m³ be retained. It is believed that if concentrations are kept below this level, the incidence of metal fume fever will be low and any attacks which may occur will be mild. The Committee suggests 10 mg/m³ as a STEL.

Other recommendations: Cook (1945), Smyth (1956) and Elkins (1959) 15 mg/m³; USSR (1967), Czechoslovakia (1969), East Germany (1973), West Germany (1974) and Sweden (1975) 5 mg/m³.

References:

1. Fairhall, L.T.: *Industrial Toxicology*, 2nd ed., p. 135, Williams & Wilkins, Baltimore, MD (1957).
2. Turner, J.A., Thompson, L.R.: *Pub. Health Bull. #157*, U.S. Pub. Health Service, Washington, DC (1926).
3. Hunter, D.: *Diseases of Occupation*, p. 421, Little, Brown, Boston, MA (1969).

ANTU

alpha-Naphthyl-thiourea

$C_{11}H_{10}N_2S$

Skin

TLV, 0.3 mg/m³

STEL, 0.9 mg/m³

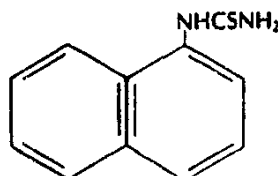
ANTU is an odorless gray powder. Its molecular weight is 202.27 and the melting point is 198° C with decomposition occurring upon boiling. Insoluble in water and only very slightly soluble in most organic solvents.

The principle use of ANTU is as an rodenticide.

McClosky *et al.*⁽¹⁾ reported that the acute oral toxicity of ANTU varies greatly among different species, rats and dogs being the most susceptible (LD₅₀, 30-50 mg/kg) and rabbits the least (1000 mg/kg). Later studies showed an acute oral LD₅₀ for monkeys of 4,250 mg/kg. The acute toxicity of ANTU for man is believed to lie somewhere between these extremes. A dietary level of 50 ppm for two years (approximately 2.5 mg/kg per day, equivalent to 170 mg/man/day) produced tissue damage in rats.⁽²⁾

Evaluation of the toxicity data for a threshold limit recommendation is further complicated by the cumulative action of ANTU on the endocrine systems (thyroids and adrenals) leading to hypothyroidism upon repeated exposure, whereas a tolerance to certain of the acute effects of ANTU (pulmonary effusion) likewise occurs.⁽³⁾

A case of contact eczema due to handling a rat poison containing ANTU as a base has been reported.⁽⁴⁾ Tests per-



formed on workers handling thiourea products showed ready penetration through the skin, leading to destructive changes in the thyroid glands.⁽⁵⁾

ANTU has been implicated⁽⁶⁾ as a causative agent in occupational bladder tumors because of its content of beta naphthylamine as an impurity in alpha naphthylamine from which ANTU is made. At the TLV of 0.3 mg/m³ it is believed that the amount of beta naphthylamine exposure would pose no carcinogenic risk provided skin contact is avoided. Other adverse effects of ANTU are believed to be protected against by the recommended TLV and the STEL of 0.9 mg/m³.

References:

1. McClosky, W.T., Smith, M.I., Lillie, R.D.: *Pub. Health Reports* 60:1101 (1945).
2. Lehman, A.J.: *Q. Bull. Assn. Food Drug Off. U.S.* 16:47 (1952).
3. Fairchild, E.J. II.: Personal communication to TLV Committee member (July 1959).
4. Laubstein, H.: *Berylsdermatosen*, 10:154 (1962).
5. Kosova, L.V.: *Gig. I Sanit.*, 35:31 (1970).
6. Case, R.A.M.: *Ann. Roy. Coll. Surg. Eng.* 39(4):213 (1966).

ARSENIC AND COMPOUNDS

As

Soluble Compounds, as As

TLV, 0.2 mg/m³

Arsenic, an element with atomic number 33, atomic weight 74.92, is in Group VA of the periodic table. The most common form of the element is a gray brittle crystalline solid with a specific gravity of 5.72, which sublimes at 613° C. It also exists in amorphous forms: black, specific gravity of 4.7 and yellow, specific gravity of 2.0, which is relatively volatile. Yellow arsenic is soluble in carbon disulfide; the other forms are insoluble in water or solvents, but dissolved by oxidizing acids.

Elemental or metallic arsenic is employed as an alloying agent for heavy metals, in special solders, and as a doping agent in silicon and germanium solid state products.

In addition to arsenic compounds discussed separately (As₂O₃, AsH₃ and lead arsenate, q.v.) many others find commercial application. The arsenites are important herbicides, calcium and other arsenates are insecticides; sulfides are pigments, rodenticides and used in pyrotechnics; gallium arsenide is in semiconductors; arsenic trichloride, a liquid with a boiling point of 130.5° C, is employed in chemi-

cal synthesis; the gaseous tri- and pentafluorides apparently have no important commercial uses. Many organic arsenic compounds, however, have been employed in medicine, or as war gases.

As with other metallic poisons, the toxicities, especially the acute toxicities, of arsenic compounds are related to their solubility in water. Thus most arsenates and arsenites are acute poisons, while the sulfides are probably less toxic in an acute sense, but may be equally hazardous on prolonged exposure. Elemental arsenic is also less acutely toxic than its oxides, except for the rare yellow arsenic which is highly toxic, possibly similar to yellow phosphorus in some of its properties.

Systemic arsenic poisoning is rarely seen in industry, and still more rarely is it severe in character. According to Hardy,⁽¹⁾ it is hard to explain the difference between industrial and nonindustrial arsenic poisoning, but such variation is recorded in all industrialized countries. The usual effects on workers are local, on skin and mucous membranes, etc. A hoarse voice is characteristic of an arsenic worker, and a perforated nasal septum is a common result of prolonged inhalation of white arsenic dust or fume. A few documented cases of cirrhosis of the liver, however, due to occupational exposure to arsenic, have been recorded.⁽¹⁾

Although the epidemiologic evidence is not complete, arsenic is considered by some to be a carcinogen, certainly

of the skin, and perhaps of the bronchi.^(2,3) Cancers from exposure to arsenic have followed: 1) the internal use of Fowler's Solution, an aromatic solution of potassium arsenite;⁽⁴⁾ 2) inhalation and skin contact with sheep-dust, a mixture of sodium arsenite and sulfur;⁽⁵⁾ 3) the combined inhalation of As_2O_3 , SO_2 and other particulates from the smelting of ores containing arsenic (see documentation, arsenic trioxide production). Experimental cancers in animals have not been produced from As_2O_3 despite several attempts⁽⁶⁻⁸⁾ and the conclusion of Vallee *et al.*⁽⁸⁾ was that "it is improbable that arsenic (*per se*) plays a significant role in the generation of cancer." The belief that other occupational factors are necessary for the development of cancer, in addition to arsenic exposure, has been expressed by others.⁽⁹⁾

A search of the world literature reveals no reports of industrial or experimental exposures solely to arsenic compounds which contain both environmental and toxicological criteria from which a TLV can be unequivocally based. Watrous and McCaughey⁽¹⁰⁾ found concentrations of arsenic in a pharmaceutical plant averaging about 0.2 mg/m^3 , with no definite evidence of intoxication. Pinto and McGill studied a group of smelter employees and found an average urinary arsenic excretion of 0.8 mg/L .⁽¹¹⁾ The chief manifestation of toxic exposure was dermatitis, with perforation of the nasal septum, pharyngitis and conjunctivitis noted less frequently. A reasonable interpretation of the urinary arsenic levels would indicate an average exposure of about 0.2 mg/m^3 of arsenic in air. Since individual concentrations as high as 4 mg/L of urine were found, it is probable that many workers were exposed at higher concentrations.

In its criteria document for inorganic arsenic, NIOSH in 1973⁽¹²⁾ recommended 0.05 mg As/m^3 (as a TWA) as a workplace air standard. This was changed in 1975 to 0.002 mg/m^3 as a 15 minute ceiling.

The first limit was based primarily on reports of cancer among workers exposed to arsenic, as well as non-occupational cancer resulting from arsenic medications. The only pertinent environmental data cited not already noted consist of an average concentration of 0.56 mg/m^3 computed from the paper by Perry *et al.*⁽¹³⁾ on an English sheep dip factory study, and a study by Lee and Fraumeni⁽¹⁴⁾ in a smelting plant. Concentrations of 1.47, 1.56 and 1.50 mg/m^3 were reported in "medium and high exposure areas" and 0.65, 0.17 and 0.002 mg/m^3 in "light exposure areas". In both plants an increased incidence of cancer was reportedly found.

The Committee is not aware of any published explanation of the reasons for the reduction of the NIOSH 1973 recommendation of a TWA of 0.05 mg/m^3 as a standard, to a ceiling of 0.002 mg/m^3 in 1975.

Normal values of arsenic in urine, as recorded in the literature, vary from 0.013 to 0.046 mg/L ,⁽¹⁾ to 0.13 ,⁽¹⁵⁾ to

0.25 .⁽¹⁵⁾ The urinary excretion, in mg/liter , of elements that are freely eliminated by this route, such as fluorine, mercury and arsenic, is at most 2.5 to 5 times the occupational exposure in $\text{mg/cubic meter of air}$.⁽¹⁶⁾ It is apparent that biological monitoring for arsenic by urinalysis would be of limited value in determining whether or not the NIOSH recommended standard was being met or exceeded.

According to the 1977 compilation of occupational exposure limits of the International Labour Office, the following countries had adopted the previous TLV of 0.5 mg/m^3 : Australia, Finland, Japan, Holland, Switzerland and Yugoslavia, Czechoslovakia, East Germany, Hungary and Poland specified the USSR MAC of 0.3 mg/m^3 ; Romania 0.2 and Sweden 0.05 mg/m^3 . Only three of 18 countries (West Germany, Italy and Sweden) designated arsenic and compounds as carcinogens, although Belgium and the Netherlands so characterized arsenic trioxide.

It is possible that some arsenic compounds, the trichloride for example, might produce certain toxic effects at concentrations below 0.2 mg/m^3 of arsenic. Data to substantiate this speculation are lacking. The contrary situation, that some compounds, or the metal itself, are chronically less toxic than As_2O_3 , the form for which most information is available, seems more probable in the light of present knowledge. Therefore, a TLV of 0.2 mg As/m^3 for soluble compounds of arsenic is recommended.

References:

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2. Buchanan, W.D.: *Toxicity of Arsenic Compounds*. Elsevier, Amsterdam, (1962). Cited in ref. 1.
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6. Hueper, W.C., Payne, W.W.: *Arch. Env. Health* 5:445 (1962)
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9. Goldblatt, M.W., Goldblatt, J.: *Occupational Carcinogenesis*, in *Industrial Medicine and Hygiene*, E.R.A. Merewether, ed., pp. 210-215, Butterworth, London (1956). Cited in ref. 1
10. Watrous, R.M., McCaughey, M.B.: *Ind. Med.* 14:639 (1945)
11. Pinto, S.S., McGill, C.M.: *Ind. Med. & Surg.* 22:281 (1953)
12. NIOSH: *Criteria for a Recommended Standard — Occupational Exposure to Inorganic Arsenic* (1973).
13. Perry, K. *et al.* *Brit. J. Ind. Med.* 5:6 (1948). Cited in ref. 12
14. Lee, A.M., Fraumeni, J.F. Jr.: *J. Natl. Cancer Inst.* 42:1045 (1969)
15. Seifert, P.: *Deut. Med. Wochschr.* 79:1122 (1954). Abstracted in *Arch. Ind. Health* 12:665 (1955).
16. Elkins, H.B.: *Am. Ind. Hyg. Assoc. J.* 28:305 (1967).

quired an 8-hour exposure at about 6000 ppm (35° C) to kill four of six rats. Signs of gross overexposure were varying degrees of ataxia, prostration, and respiratory distress followed by narcosis. Those that survived appeared to recover without significant signs of exposure.⁽¹⁾

Shell Chemical Corporation⁽¹⁾ presents the following observations in respect to sensory responses reported by unconditioned personnel during or following 5-minute exposures to the vapor:

Threshold, odor	6 ppm
50% Threshold, eye irritation	50 ppm
50% Threshold, nose irritation	50 ppm

No incidents of illness caused by industrial handling of EAK have been reported. Workers may complain of odor

and transient eye irritation when handled in poorly ventilated areas when the concentration exceeds 25 ppm, but experience shows that transient responses do not lead to significant systemic effects.⁽¹⁾

Accordingly, the TLV of 25 ppm is recommended as a comfort level for unconditioned workers.⁽²⁾

References:

1. *Industrial Hygiene Bulletin* SC:57:59, Shell Chemical Corporation, NY (March 1958).
2. Communication from O.M. Banks, Ind. Hygienist, Shell Chemical Corporation, (May 20, 1965).

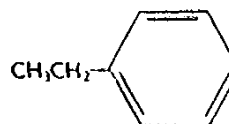
ETHYL BENZENE

Phenylethylene

C_8H_{10}

TLV, 100 ppm (≈ 435 mg/m³)

STEL, 125 ppm (≈ 545 mg/m³)



Ethyl benzene is a colorless, flammable liquid with an aromatic odor. It has a molecular weight of 106.16, a specific gravity of 0.86258 at 25° C and a vapor pressure of 7.1 mm Hg at 20° C. The vapor density is 3.7 times that of air. "Saturated" air with the vapor at 26° C and 760 mm is 1.32%. It boils at 136.2° C and freezes at -95.01° C. The closed cup flash point is 63° F, autoignition temperature is 810° F and is a fire risk.⁽¹⁾ Ethyl benzene is only slightly soluble in water at 15° C (14 mg/100mL), but is miscible with alcohol and ether.

This compound is employed as a solvent and as an intermediate in the production of styrene.

Ethyl benzene toxicity is characterized by its irritancy to the skin, and less markedly, to the mucous membranes. Repeated application of the liquid to the skin of rabbits causes reddening and some exfoliation and blistering.⁽²⁾ Oettel⁽³⁾ characterized ethyl benzene as the most severe irritant of the benzene series.

On the eyes and nose, the vapor at 5000 ppm causes intolerable irritation; at 2000 ppm, eye irritation and lacrimation are immediate and severe, and are accompanied by moderate nasal irritation, decreasing somewhat in several minutes; at 1000 ppm, irritation and tearing, but tolerance develops rapidly; and at 200 ppm, the vapor has a transient irritant on human eyes.⁽¹⁾

Like benzene, its acute toxicity is low; the dose fatal to guinea pigs in a few minutes was 10,000 ppm⁽⁴⁾ and 5000 ppm dangerous to life in 30 to 60 minutes; animals dying

from exposure had intense congestion and edema of the lungs, and generalized visceral hyperemia. The narcotic dose for animals was 10,000 ppm, reached in 18 minutes, preceded by vertigo, unsteadiness and ataxia.

Chronic inhalation exposure of guinea pigs, monkeys, rabbits and rats at concentrations from 400 ppm to 2,200 ppm, seven to eight hours/day, five days/week for as long as six months, produced no effects in all species except the rat, which showed a slight increase in the weights of the kidneys and livers, on the average, for those exposed at 400 ppm for 186 days. The investigators concluded that 400 ppm was the *beginning effect* level for chronic inhalation of the vapor.⁽²⁾

It is apparent that, as no systemic effects can be expected at levels producing distinctly disagreeable skin and eye irritation, the TLV must be based on the latter effects. For the prevention of disagreeable irritation, a TLV of 100 ppm and a STEL of 125 ppm are recommended.

Other recommendations: Czechoslovakia (1976) 45 ppm, Poland (1975) 25 ppm.

References:

1. Gerarde, H.W.: *Industrial Hygiene & Toxicology*, 2nd ed., Vol II, p. 1231, Interscience, NY (1963).
2. Wolf, M.A. et al: *Arch. Ind. Health* 14:387 (1956).
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4. Yant, W.P., Schrenk, H.H., Waite, C.P., Patty, F.A.: *Pub. Health Rept.* 45:1241 (1930).

001567

METHYLENE CHLORIDE

CAS 75-09-2

Dichloromethane

CH_2Cl_2

TLV, 100 ppm ($\approx 360 \text{ mg/m}^3$)

STEL, 500 ppm ($\approx 1700 \text{ mg/m}^3$)

Methylene chloride is a colorless, volatile liquid. Its molecular weight is 84.9; specific gravity 1.33 at 20°/4° C; boiling point 40° C at 760 torr; and the melting point -96.7° C. Because of its high vapor pressure (440 torr at 25° C), substantial vapor concentrations are readily achieved. It is not flammable by standard tests in air, but will burn under extreme conditions. Completely miscible with most organic solvents, methylene chloride is soluble in water only 1% by weight.

Methylene chloride is widely used in paint removers, as a solvent for plastics, as a degreasing agent, in propellant mixtures for aerosol sprays, and as a blowing agent in foams. The odor, although distinctive, is not a good indication of exposure since concentrations of 100 ppm reportedly are not easily perceptible to most people. Above 300 ppm most persons detect the odor.

Liquid methylene chloride is painful and irritating if splashed in the eyes or if confined on the skin by gloves, clothing, or paint remover formulations. A burn can result if it is not promptly removed from the eyes and skin. The acute oral LD_{50} for rats is about 2000 mg/kg.

According to Lehmann and Flury,⁽¹⁾ slight narcosis occurs at 4000 to 6100 ppm in several species of animals. The fatal concentration for seven hours' exposure is about 15,000 ppm.⁽¹⁻³⁾ Rats exposed 75 days (8 hours a day) at 1300 ppm showed slight liver changes which were not found at 50 days.⁽¹⁾ Cats exposed four to eight days at 7200 ppm for four weeks were found to have kidney and liver changes. Heppel and associates⁽⁴⁾ found that daily seven-hour exposures at 5000 ppm for six months had no discernible effect on dogs and rabbits, and only reduction in the rate of growth of guinea pigs. At 10,000 ppm, four hours a day, for seven and one-half weeks, dogs and guinea pigs, but not monkeys, rabbits or rats developed liver injury.

High exposures produced tumors in animals, but the investigators concluded CH_2Cl_2 is not likely to be a carcinogen under reasonable use conditions. Nearly 2000 male and female rats and hamsters were exposed by inhalation to 0, 500, 1500, or 3500 ppm of methylene chloride vapors six hours/day, five days/week for up to two years.⁽⁵⁾ The liver was the primary target organ in rats with slight exposure-related effects in both sexes at 500, 1500, or 3500 ppm. Liver effects included increased hepatocellular vacuolization (consistent with fatty change) in both sexes at 500, 1500, or 3500 ppm, increased multinucleated hepatocytes in the central lobular region in females exposed to 500, 1500, or 3500 ppm and increased foci and areas of altered hepatocytes in females exposed to 3500 ppm. Liver effects first appeared after 12 months of exposure, progressed slightly from 12 to 18 months, but were unchanged in severity thereafter. There was no increase in hepatocellular carcinomas. A primary target organ was not found in hamsters of either sex. The only effects observed at all levels were

primarily the result of decreased amount of amyloid (a naturally occurring geriatric disease). The number of female rats with a benign tumor did not increase in the exposed versus the control animals, but the total number of benign mammary tumors was increased at the 500, 1500, or 3500 ppm levels. The effect was observed to a lesser extent in male rats, and was only apparent in the 1500 and 3500 ppm groups. This effect was not present in the hamsters of either sex. There was no increase in malignant mammary tumors in any group exposed to methylene chloride. Male rats exposed to 1500 or 3500 ppm appeared to have an increased number of sarcomas (malignant mesenchymal tumors) in the ventral neck region in or around the salivary glands. There were 1, 0, 5, and 11 sarcomas in the 124 male rats per group exposed to 0, 500, 1500, or 3500 ppm, respectively. The increase at the high dose was statistically significant. No increase was observed in these tumors in the female rats or either sex of hamsters.

Methylene chloride caused increased reversions in an Ames *in vitro* mutagenic screen with *Salmonella typhimurium*, but activity was only slightly increased by addition of rat liver homogenate. There was no increase in cytogenic aberrations in the bone marrow cells of rats repeatedly exposed for six months to 500, 1500, or 3500 ppm in the lifetime study.⁽⁵⁾

No teratogenic effects have been observed⁽⁶⁾ in pregnant rats exposed to 4500 ppm during critical periods of gestation. These results confirmed those found in a previous study⁽⁷⁾ carried out at 1250 ppm on pregnant rats and mice.

The metabolism of methylene chloride to carbon monoxide and the subsequent production of carboxyhemoglobin has been studied in animals and man. In the rat, metabolism appears to be saturable with disproportionately less carboxyhemoglobin formed and more unchanged methylene chloride expired as exposure increased.⁽⁸⁾

Moskowitz and Shapiro⁽⁹⁾ reported four cases of poisoning with one fatality, apparently due to narcotic action. Collier⁽¹⁰⁾ reported two cases of poisoning in painters who suffered from headache, giddiness, stupor, irritability, numbness, and tingling in the limbs. Kuzelova and Vlasak⁽¹¹⁾ noted complaints of headache, fatigue, and irritation of the eyes and respiratory passages by workers exposed at concentrations up to 5000 ppm. Neurasthenic disorders were found in 50%, and digestive disturbances in 30% of the persons exposed. Three acute poisonings, one involving loss of consciousness, were recorded without serious after-effects. Generally, there has been complete recovery if exposure is terminated before anesthetic death occurs.

Weiss⁽¹²⁾ stated that a chemist after a year's exposure developed toxic encephalosis with acoustical and optical delusions and hallucinations. Concentrations frequently exceeded 500 ppm; values of 660 ppm, 800 ppm, and near the floor, 3600 ppm were noted.

Golubovski and Kamchatnova⁽¹³⁾ found liver disease in workers exposed to methylene chloride and methanol which they attributed to the former. Exposure concentrations were not reported.

In the early 1940's, methylene chloride was considered the least toxic of the chlorinated hydrocarbon solvents when a safe industrial air limit of 500 ppm was proposed by Heppel *et al.*⁽⁴⁾ and later adopted by the TLV Committee as protective enough to prevent any significant narcotic effects or liver injury.

Subsequently, Stewart *et al*⁽¹⁴⁾ reported that significant quantities of carbon monoxide and carboxyhemoglobin (COHb) were produced in humans receiving single exposures at 500-1000 ppm of methylene chloride. The COHb concentrations reported by Stewart approximated those considered objectionable if due to inhalation of carbon monoxide.

More extensive examination of CO production from methylene chloride was later reported by the same investigators.⁽¹⁵⁾ Human volunteers exposed to methylene chloride at 1000 ppm for two hours (2000 ppm-hours, one-half of the Ct permitted for an 8-hour exposure at 500 ppm) resulted in COHb levels in excess of those permitted in industry from exposure to CO alone.

This finding of the body's capacity to metabolize methylene chloride to CO was confirmed by Ratney *et al*⁽¹⁶⁾ in a small group of workers exposed to 180 to 200 ppm methylene chloride. Such daily, repeated exposures resulted in equilibrium blood concentrations of COHb of 9% that decreased to half that value by next day's start of work, indicating a possible secondary source of carbon monoxide such as auto exhaust or smoking. The differential increment in percent COHb of 4.5% from a day's exposure at 180 to 200 ppm of methylene chloride is approximately the same as that developed from a daily exposure to CO at its TLV of 50 ppm.

DiVincenzo⁽¹⁷⁾ found that humans exposed to 100 ppm methylene chloride for 8 hours had a COHb value of $3.22\% \pm 0.22\%$, whereas an 8-hour exposure at 150 ppm produced $5.39\% \pm 0.06\%$ level and an 8-hour exposure at 200 ppm resulted in COHb level of $6.8\% \pm 0.65\%$.

In an extensive study several healthy adults of both sexes were exposed from 2-10 times to methylene chloride vapor concentrations of 0, 50, 100, 250, or 500 ppm for periods of 2, 3, and 7.5 hours in a controlled environment chamber. These studies were designed to simulate the type of exposure encountered in the industrial setting and consisted of both steady and fluctuating vapor concentrations. Exposure resulted in a prompt elevation of COHb. The elevation persisted longer than COHb from CO alone since metabolism of the absorbed methylene chloride continued after exposure ceased. This solvent-induced COHb is apparently added to the body burden of carbon monoxide derived from other sources.

This study corroborated previous single exposure studies in that no deleterious effects upon the health or performance of healthy adults could be detected when they were repeatedly exposed to 250 ppm or less for 7.5 hours per day, five days per week for two weeks, or in the case of the male subjects, to 500 ppm on two consecutive days.⁽¹⁸⁾ Among the parameters studied were complete blood count, clinical chemistry (SMA 12), EKG, serum triglycerides, blood pressure, subjective signs and symptoms, urinalysis (Combistix®) urinary urobilinogen, neurological tests, EEG, visual evoked response, pulmonary function and cognitive, alertness, time estimation, coordination, arithmetic, and inspection tests.

The increase in COHb was related to the magnitude of the vapor exposure. Both duration of exposure and vapor concentration were factors. Seven and one-half hour exposures to concentrations of 100 ppm for 5 days resulted in COHb elevation of about 5% in nonsmokers. The odor was

not objectionable at 250 ppm and many subjects could not detect it at 50 or 100 ppm.

A retrospective mortality study⁽¹⁹⁾ of a methylene chloride exposed population in the manufacture of film showed no solvent related increase in death due to any specific causes. Over 30% of the exposed population had worked a minimum of 20 years by 1964. In addition to close health follow-up of all methylene chloride exposed persons from that time on, the long-term segment of the population represented occupational exposures of over 30 years ranging from 30-125 ppm time-weighted averages. Alleged effects on the heart are not substantiated by this study since circulatory disease deaths were significantly less among exposed employees than expected for the general state population and comparable to other employees in the same location who were not exposed to methylene chloride. There was no indication of solvent-related carcinogenicity.

Combined CO and the CH₂Cl₂ exposures yield additive increases in the COHb levels with rats. Appropriate equation for mixtures should be used to determine if the mixed exposure to CH₂Cl₂ and CO is acceptable.

A time-weighted average TLV of 100 ppm is recommended for methylene chloride in the absence of occupational exposure to carbon monoxide. In view of the long history of use of methylene chloride without documentation of health related injuries using the TLV guidelines, a 100 ppm eight-hour time-weighted average exposure should not pose a problem to this occupational work force.

A STEL of 500 ppm is recommended since neither undesirable CNS responses nor excessive carboxyhemoglobin values are expected with such short-term exposures to methylene chloride.^(18, 20, 21) Concurrent exposure to other source of carbon monoxide or physical activity will require assessment of the overall exposure and adjustment for the combined effect for both the TWA and STEL.

Other recommendations: NIOSH (1976) 75 ppm; West Germany (1979) and Elkins (1959) 200 ppm; ANSI (1969) 500 ppm; USSR (1970) 15 ppm; East Germany (1973), Romania (1975), Yugoslavia (1971), and Czechoslovakia (1976) 140 ppm; Sweden (1974) 100 ppm.

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APPENDIX IV

OPERATION AND FIELD MANUAL
FOR hNu PID AND FOXBORO OVA

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FIELD INVESTIGATIONS OF UNCONTROLLED HAZARDOUS WASTE SITES

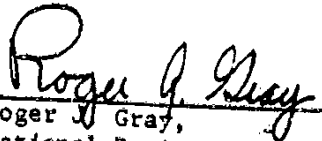
FIT PROJECT

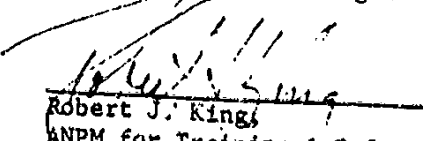
FIT OPERATION AND FIELD MANUAL

hNu Systems PI 101 Photoionization Detector
and
Century Systems (Foxboro) Model OVA-128
Organic Vapor Analyzer

March, 1982

Approved for Use


Roger J. Gray,
National Project Manager


Robert J. King,
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International Specialists in the Environmental Sciences

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SECTION 1

INTRODUCTION TO THE ORGANIC VAPOR ANALYZER

1.1 PERSONNEL

The following discussion is intended for personnel having prior experience with gas chromatography and specifically trained in the use of the Century Systems (Foxboro) Model OVA-128 Organic Vapor Analyzer (hereafter referred to as "OVA"). It is Field Investigation Team (FIT) Project policy that personnel not trained in the use of the OVA will not be permitted to operate the equipment. (See FIT Project Communique, Field Operations No. 1, 22 January 1982, for a listing of currently certified Ecology and Environment (E & E) personnel.)

1.2 THEORY OF OPERATION

1.2.1 General

The OVA is designed to detect, measure, characterize, and identify organic gases and vapors found in the ambient air. Its application is broad, since it has a chemically resistant sampling system and it can be calibrated to quantitatively respond to many different organic compounds. It is extremely sensitive, and in the "survey mode" it provides an accurate indication of organic gas and vapor concentrations in three ranges: 0 to 10 ppm, 0 to 100 ppm, and 0 to 1000 ppm. While designed as a lightweight, portable instrument, it can be readily adapted to remote monitoring applications. In addition, the OVA can function as a gas chromatograph ("GC mode") and can thus be used to characterize and identify organic material.

1.2.2 Flame Ionization Detector (FID)

The OVA uses the principle of hydrogen flame ionization for the detection and measurement of organic compounds. The FID system consists of a diffusion flame of pure hydrogen and air which is free of ions and therefore non-conducting. When a sample of organic material is introduced into the flame, ions are formed, causing the flame to become conductive. The flame's conductivity is related to many factors, including the number of carbon atoms present and the efficiency of combustion, and

is proportional to the number of positively charged carbon atoms generated during combustion. This conductivity is measured by collecting the positively charged ions on a negative electrode. As the ions are collected, a current is generated and measured with a linear electrometer preamplifier. The output of the preamplifier is amplified and applied to a meter or an external recorder, which gives a visual indication of the total concentration of hydrocarbon species.

In a typical laboratory FID, the sample is entirely mixed with hydrogen prior to introduction to the burner. This premixing does not occur in the OVA, but rather the sample and combustion air are introduced into the burner through a porous bronze filter which disperses the sample and combustion air around the hydrogen flame. This method of sample introduction modifies the typical ion formation process, and as a result, the OVA responds differently than a laboratory FID. One hypothesis is that the size of the reaction envelope and the energy available from the hydrogen are altered, allowing less contact time and reducing the number of ions formed. In a laboratory FID, for example, propane (C_3H_8) would have a response three times that of methane (CH_4). In the OVA, however, propane has a response approximately two-thirds that of methane. In general, the OVA has a response for nearly all common hydrocarbons of between 50% and 250% of the response of methane. The response of the OVA to all classes of organic molecules is reproducible. For routine operation, the OVA is calibrated to methane (CH_4). Table 1-1 lists the responses to several common organic compounds. The OVA has negligible responses to carbon monoxide, carbon dioxide, nitrogen, helium, etc., as well as any molecule which, due to its structure, does not produce ions in the detector flame.

1.2.3 Survey Mode

In the survey mode, the OVA is a total hydrocarbon analyzer and monitors the total amount of ambient organic gases and vapors. It provides a continuous, direct readout of their concentrations expressed as methane equivalent or as the equivalent concentration of any organic compound used to calibrate the instrument (FIT Project OVA's are calibrated to methane). A continuous sample is drawn into the instrument through the probe and sample loop and is transmitted to the detector chamber by

TABLE 1-1

RESPONSE OF THE OVA TO SEVERAL COMMON ORGANIC COMPOUNDS

Compound	Relative Response CH ₄ = 100
<u>Hydrocarbons</u>	
Methane	100 (reference)
Propane	64
N-butane	61
N-pentane	100
Ethylene	85
Acetylene	200
Benzene	150
Toluene	120
Ethane	90
<u>Ketones</u>	
Acetone	60
Methyl ethyl ketone	80
Methyl isobutyl ketone	100
<u>Alcohols</u>	
Methyl alcohol	15
Ethyl alcohol	25
Isopropyl alcohol	65
<u>Halogen Compounds</u>	
Carbon tetrachloride	10
Chloroform	65
Trichloroethylene	70
Vinyl chloride	35

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means of an internal pumping system. The output of the detector is indicated on the meter display, which is an integral part of the Probe/Read-out Assembly. The scale of the meter reads directly in parts of organic contaminant per million parts of air (ppm), modified by the range switch on the instrument body.

Note that in the absence of a suitable analytical standard, the concentrations of total hydrocarbons are expressed as ppm CH₄ equivalent.

1.2.4 Gas Chromatograph (GC) Mode

In the GC mode, the OVA functions as a completely portable, self-contained gas chromatograph for gas or vapor samples only. With the judicious use of qualitative standards and the proper selection of columns, individual organic compounds can be identified. Plots of the retention time of various organic compounds versus physical properties such as carbon number, boiling point, etc., can be used to identify classes of organic compounds.

A sample can be introduced into the OVA either via the 250-microliter (ul) sample or the injection port. When the OVA is operating in the survey mode, the sample is continuously flowing through the sample loop. By depressing the "inject" button, the sample loop is immediately connected to the column, causing a 250 ul aliquot of the sample to be injected into the column. The OVA also has an ambient temperature injection port and septum. A gas-tight syringe is used to inject a sample directly into the column through the length of the injection port. Injections of greater than 150 to 200 ul have been found to extinguish the flame (further guidance on injection size is presented in Section 6.2).

The column consists of an inert tubing packed with a material which physically interacts with organic compounds. Since the packing material has a different affinity for each individual compound, the time it takes each compound to pass through the length of the column (the retention time) will be different. The retention time is dependent upon several physical parameters of the column: temperature, length of column, type of packing, and flow rate of carrier gas.

By comparing the retention time of an unknown compound to that of known compounds, the unknown may be identified. It is important to note that a single retention time match does not constitute a positive identi-

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fication. The American Society for Testing Materials (ASTM) requires that the retention time of an unknown be established on three separate columns (high-, intermediate-, and low-polarity) before a positive identification can be made. Even after this stringent identification, the data may not hold in a court of law. However, a qualified chemist can be reasonably certain in most instances that with a good retention time match, an identification has been made. The expertise of the chemist making the assignment is the factor at work. For a positive identification of a chemical compound, a gas chromatography/mass spectrometry (GC/MS) identification is required. This constraint by no means reduces the usefulness of the OVA in the FIT program, as demonstrated in the remaining sections.

1.3 OPERATION OF THE OVA

1.3.1 Description

The basic instrument consists of three assemblies: the Probe/Readout Assembly, the Side Pack Assembly, and the Strip Chart Recorder. The output meter and alarm level adjustments are incorporated in the Probe/Readout Assembly, which is operated with one hand. The Side Pack Assembly contains the remaining operating controls and indicators, the electronic circuitry, detector chamber, hydrogen fuel supply and electrical power supply. A battery test feature allows charge condition to be read on the meter. Hydrogen flame-out is signified by an audible alarm plus a visual indication on the meter. The instrument contains a frequency modulated detection alarm which can be present to sound at a desired concentration level. The instrument is designed for one-person, one-hand operation, and the entire unit weighs less than 12 pounds, including fuel supply and battery. An earphone is provided for "operator only" monitoring, and a carrying case is provided for the transportation and storage of the instrument.

During use, the Side Pack Assembly can either be slung over the operator's shoulder or carried as a back pack. The Side Pack Assembly is housed in a high-impact plastic case and weighs less than 10 pounds. The Probe/Readout Assembly can be detached from the Side Pack Assembly and broken down for transportation and storage. The Strip Chart Recorder is used for operation in the GC mode.

The length of the telescoping probe is adjustable over a wide range to suit the individual user. A knurled locking nut is used to lock the probe at the desired length. The probe is attached to the Readout Assembly using a knurled locking nut. For measurements in closed areas, the probe is replaced with a closed area sampler, which is supplied as a standard accessory.

The primary filter is made of porous stainless steel and is located behind the sample inlet connector. In addition, replaceable porous metal filters are installed in the closed area samplers and the tubular sampler.

1.3.2 Specifications

Following are the specifications for the Century Systems (Foxboro) Model OVA-128:

- o Sensitivity: 0.1 ppm (methane) (for survey mode use)
- o Response time: Less than 2 seconds
- o Readout: 0 to 10 ppm, 0 to 100 ppm, 0 to 1000 ppm, 250° linear scaled meter; external monitor connector
- o Sample flow rate: Nominally 2 units
- o Fuel supply: 75 cubic centimeter tank of pure (99.999%) hydrogen at maximum pressure of 2300 psig, refillable while in case.
- o Primary electrical power: Rechargeable and replaceable battery pack at 12 VDC.
- o Service life: 8 hours minimum operating time with hydrogen supply and battery power.

1.3.3 Controls (Refer to Figure 1-1)

Side Pack Assembly

Following is a description of the operation of the controls on the

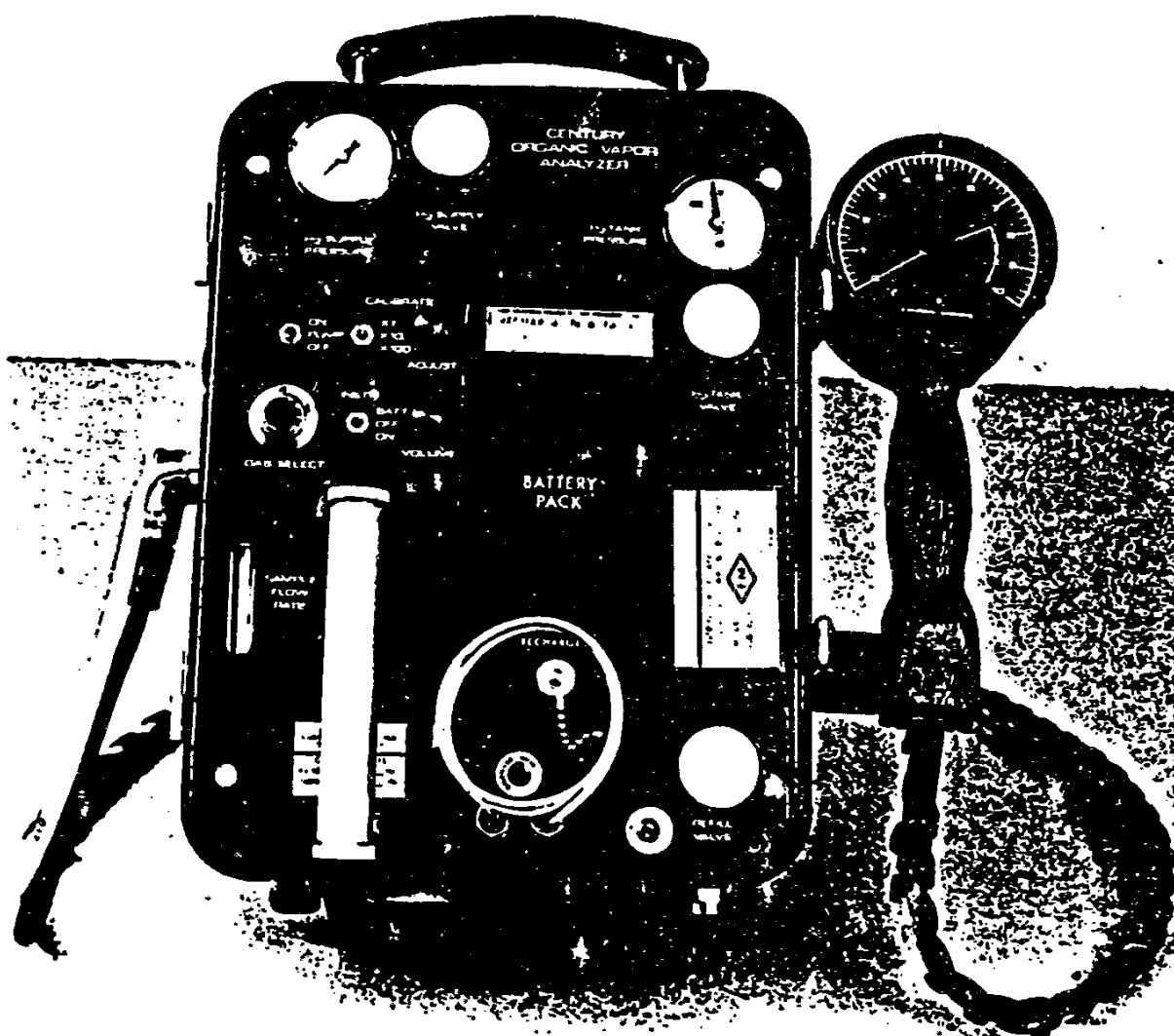


Figure 1-1 MODEL OVA-128 ORGANIC VAPOR ANALYZER

Side Pack Assembly:

- o INSTR/BATT Test Switch: Three-position toggle switch turns on all instrument electrical power except the pump and alarm power and also permits display of the battery charge condition on the readout meter.
- o PUMP (ON-OFF) Switch: Toggle switch turns on power to the internal pump and audio alarms.
- o IGNITER Switch: Momentary push-button switch connects power to the igniter coil in the detector chamber and simultaneously disconnects power to the pump.
- o CALIBRATE Switch (Range Selector): Three-position toggle switch selects the desired range: X1 (0 to 10 ppm), X10 (0 to 100 ppm), or X100 (0 to 1000 ppm).
- o CALIBRATE ADJUST (Zero) Knob: Potentiometer is used to "zero" the instrument.
- o GAS SELECT Knob (Span Control): Ten-turn dial-readout potentiometer sets the gain of the instrument, commonly referred to as span control.
- o RECORDER CONNECTOR: Amphenol connector is used to connect the instrument to an external monitor with the following pin connections:
 - Pin E - Plus 12 VDC
 - Pin H - Ground
 - Pin B - Signal 0-5 VDC
- o RECHARGER CONNECTOR: BNC connector is used to connect the battery pack to the battery recharger assembly.

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- o H₂ TANK VALVE: Valve is used to supply or close off the fuel supply from the hydrogen tank.
- o H₂ TANK PRESSURE Indicator: High pressure gauge measures the pressure in the hydrogen fuel tank. The pressure is an indication of fuel supply.
- o H₂ SUPPLY VALVE: Valve is used to supply or close off the hydrogen fuel to the detector chamber.
- o H₂ SUPPLY PRESSURE Indicator: Low pressure gauge is used to monitor the hydrogen pressure at the capillary restrictor.
- o SAMPLE FLOW RATE Indicator: Indicator is used to monitor the sample flow rate.
- o REFILL CONNECTION: Quarter-inch AN fitting is used to connect the hydrogen refill hose to the instrument.
- o REFILL VALVE: Valve is used to open one end of the instrument fuel tank for refilling with hydrogen.
- o EARPHONE JACK: Jack is used to connect the earphone; the speaker is turned off when the jack is connected.
- o VOLUME Knob: Potentiometer adjusts the volume of the internal speaker and earphone.
- o READOUT and SAMPLE CONNECTORS: Used to connect the sample hose and umbilical cord from the Probe/Readout Assembly to the Side Pack Assembly.
- o SAMPLE INJECT VALVE: When this valve is depressed, a 250 ul aliquot of the sample stream is injected on-column.
- o BACKFLUSH VALVE: Reverses the flow of carrier gas (H₂) through the column while maintaining carrier gas flow to the detector.

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Probe/Readout Assembly

The controls on the Probe/Readout Assembly are:

- o METER: 250° linear scaled meter displays the output signal level in ppm.
- o ALARM LEVEL ADJUST Knob: Potentiometer (located on the back of the Readout Assembly) is used to set the concentration level at which the audible alarm is actuated.

1.3.4 Charging with Hydrogen

A high-grade dry hydrogen (99.999%) intended for use in gas chromatography is required. The maximum hydrogen pressure the instrument can handle is 2300 psig. The following procedure is used to fill the instrument with hydrogen:

- (1) Connect fill hose to REFILL CONNECTION on Side Pack Assembly.
- (2) Open H₂ supply bottle valve slightly.
- (3) Open REFILL VALVE and H₂ TANK VALVE on instrument panel.
- (4) Place FILL/BLEED VALVE on fill hose in FILL position (Pressure gauge reading on instrument panel will be equal to H₂ supply bottle pressure reading).
- (5) Shut REFILL VALVE, FILL/BLEED VALVE and H₂ supply bottle valve.
- (6) Turn FILL/BLEED VALVE on fill hose to BLEED position. Allow fill hose to bleed to atmospheric pressure.
- * (7) Turn FILL/BLEED VALVE to FILL position.
- * (8) Turn FILL/BLEED VALVE to BLEED position.
- * (9) Turn FILL/BLEED VALVE to OFF position.

(10) Close H₂ TANK VALVE

The steps marked by an asterisk (*) together allow the bleeding of hydrogen under high pressure from the connection fittings into the hose assembly and the bleeding of hydrogen in the fill hose to atmospheric pressure.

With the H₂ TANK VALVE and the H₂ SUPPLY VALVE closed, a small amount of hydrogen at high pressure will be present in the regulators and plumbing. As a leak check, observe the H₂ TANK PRESSURE indicator with the H₂ TANK VALVE open while the remainder of the system is shut down. If the pressure decreases rapidly (greater than 350 psig/hr), there is a significant leak in the hydrogen supply system.

1.3.5 Hydrogen Supply Considerations

Regional personnel should request that the Regional Administrative Manager (RAM) check the office space lease specifications to determine if the storage of a compressed cylinder of hydrogen is permitted on the office premises. The most readily obtainable hydrogen supply is a cylinder containing approximately 250 cubic feet of hydrogen at 2200 psi. A cylinder of this size will supply one OVA for over a year.

If available, a smaller cylinder of hydrogen should be obtained, since it is easier to transport to field locations. A FIT Communique will be issued on procedures for transporting hydrogen in the FIT van. If a supply cylinder is unavailable at a field operation, local hospitals or laboratories may be contacted as a possible source.

1.3.6 Battery Charging

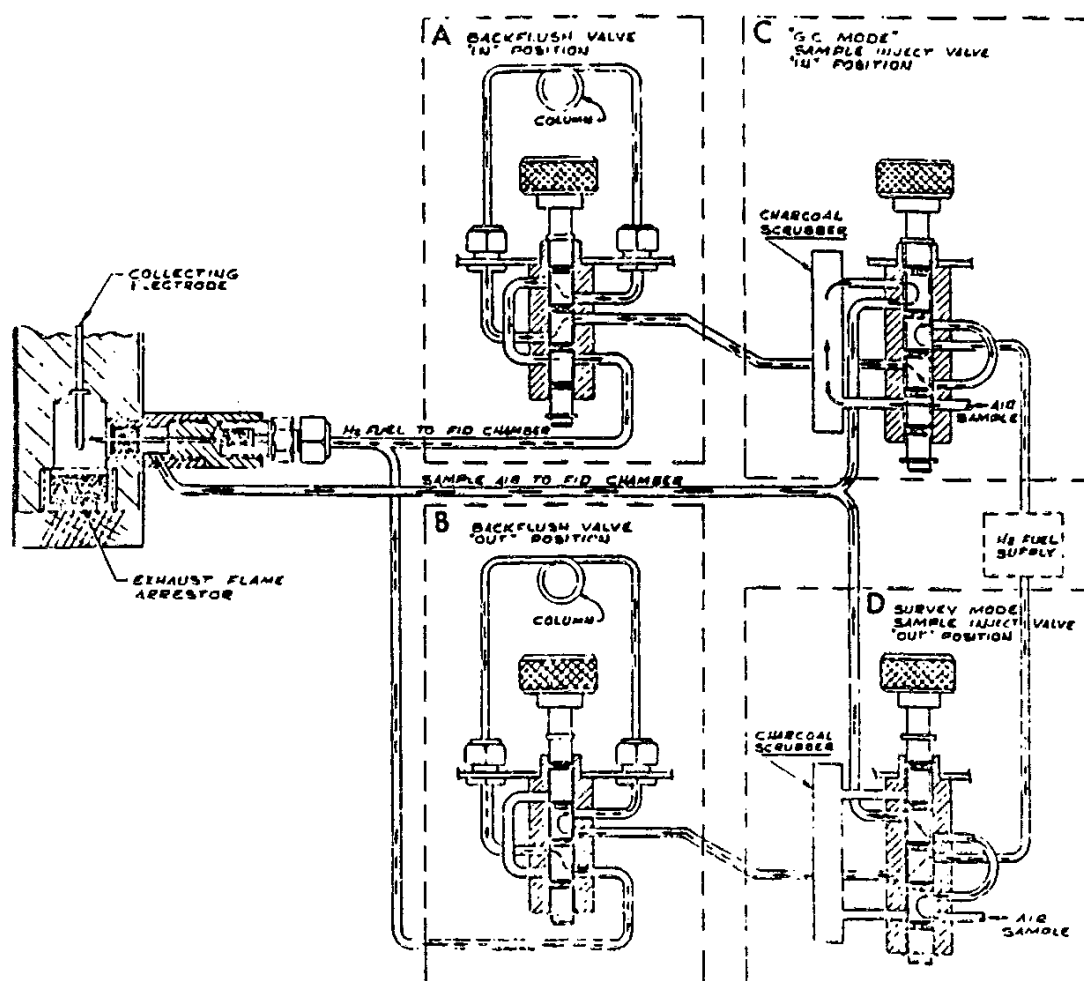
Plug the charger BNC connector into the mating connector on the OVA Side Pack Assembly. Plug the battery charger into a 115 VAC outlet and turn the battery charger switch ON. The light above the switch button will light. The condition of the battery is indicated by the meter on the charger. When the instrument is fully charged, the needle will line up with the "charged" marker. Approximately one hour of charging time is required for each hour of operation. Since the charger can be left on indefinitely without damaging the batteries, the instrument can be operated from a 120 VAC power source. FIT OVA's will always be left on charge.

1.3.7 Start-up (Survey Mode)

The following is the procedure for using the OVA in the survey mode as a portable total hydrocarbon analyzer. Figure 1-2 (D) presents a schematic flow diagram for operation in the survey mode. See Section 1.3.9 for operating the unit in the GC mode.

- (1) Assemble the instrument by connecting the Probe/Readout connectors (electrical and Swagelock®) to the Side Pack Assembly. Connect the appropriate probe to the Probe/Readout Assembly.
- (2) Turn the PUMP switch ON and leak-check the flow system by plugging the end of the probe momentarily. The SAMPLE FLOW RATE indicator should drop to zero. Turn PUMP switch OFF.
- (3) Move INSTR switch ON and allow 5 minutes for warmup.
- (4) Turn PUMP switch ON and verify that the battery is charged.
- (5) Check SAMPLE FLOW RATE indicator for proper flow.
- (6) Set CALIBRATE switch to X10; use CALIBRATE knob and set meter to read 0.
- (7) Place BACKFLUSH and INJECT valves in UP position.
- (8) Open H₂ TANK VALVE and H₂ SUPPLY VALVE.
- (9) Depress IGNITER button. If unit is in proper working order, the FID will ignite in 1 to 6 seconds. Do not depress the button longer than 6 seconds. If the instrument does not light, allow the unit to run for several minutes and repeat ignition.

NOTE: It is especially important that the INJECT VALVE be in the UP position. When this valve is in the DOWN position, ambient air is directed through the activated charcoal filter before going to the detector. Consequently, many volatile contaminants would be



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Figure 1-2 SCHEMATIC FLOW DIAGRAMS:
SURVEY MODE AND GC MODE

"scrubbed out," and the OVA would indicate background levels unless methane was the primary contaminant.

1.3.8 Shut-down

Following is the shut-down procedure:

- (1) Close H₂ SUPPLY VALVE and H₂ TANK VALVE (Don't overtighten valves).
- (2) Turn INSTR switch OFF.
- (3) Wait 10 seconds and turn PUMP switch OFF.

1.3.9 Gas Chromatographic Mode (GC Mode)

In the GC mode, the OVA functions as a gas chromatograph. Gas chromatography is an art, and in general, there are no rigid procedures for all applications. The amount of information obtained from the gas chromatograph is directly proportional to the experience of the operator. The following discussion summarizes the basic operating procedures for the OVA's GC mode. Specific procedures for GC mode operation in the FIT Project are covered in Sections 4 through 8.

Operation

The unit will function as a gas chromatograph after the following steps are taken:

- (1) Connect the Strip Chart Recorder to the Side Pack Assembly.
- (2) Connect the appropriate column to the instrument (see Section 5.5, "Column Selection").
- (3) Follow Steps 1 through 8 in Section 1.3.7.
- (4) Leak-check the column connections using an appropriate solution.
- (5) Perform Steps 9 and 10 in Section 1.3.7.
- (6) Zero the Strip Chart Recorder on the appropriate range (HI or LOW; X1, X10, or X100).

Sample Injection

There are two basic methods of presenting a sample to the gas chromatograph for analysis: via the SAMPLE INJECT VALVE or via a gas-tight syringe.

SAMPLE INJECT VALVE. This valve allows a 250 ul aliquot of the sample flowing to the detector to be introduced to the column. Once the sample is injected, the GC analysis is automatic.

- (1) Simultaneously turn on the Strip Chart Recorder and depress the SAMPLE INJECT VALVE with a fast, positive motion.
- (2) If the FID flame goes out (as indicated by a sharp drop in the concentration level), re-ignite the flame immediately.
- (3) A negative air peak and positive compound peaks will be indicated on the Strip Chart Recorder. Adjust the CALIBRATE switch on the Side Pack Assembly and the HI-LO switch on the Strip Chart Recorder to keep the peaks on-scale.

After the final peak of interest, it is necessary to activate the BACKFLUSH VALVE, which reverses the flow of carrier gas (H_2) through the column while maintaining flow to the detector. This process should be allowed to occur for 1.5 times the length of the chromatogram in order to "purge" the column prior to making subsequent injections. Following the backflush, return the INJECT VALVE to the UP position. (Figure 1-2(C) illustrates flow directions in the GC mode.)

Gas-Tight Syringe. Using a gas-tight syringe, a premeasured amount of sample can be injected directly on column. Good syringe technique is very important for sample introduction via a gas-tight syringe.

- (1) Leak-check the gas-tight syringe by inserting the needle into an old septum and depressing the plunger. There should be a pressure buildup.
- (2) Check for flow in the syringe by placing the needle tip into a small amount of de-ionized water and depressing the plunger. A flow of bubbles should be observed.

- (3) Collect the appropriate amount of sample in the syringe.
- (4) Place the BACKFLUSH VALVE and the INJECT VALVE in the UP position. (For syringe injections, the BACKFLUSH VALVE must be in the UP position in order to run a chromatogram.)
- (5) Inject the sample through the injection port and septum with a smooth, swift motion. Simultaneously start the Strip Chart Recorder.
- (6) If the FID flame goes out as indicated by a sharp drop in the concentration level (meter needle falls below zero), re-ignite the flame immediately. If the flame cannot be re-ignited, backflush the column for several minutes. Re-ignite the flame and make a new injection.
- (7) A negative air peak and positive compound peaks will be indicated on the Strip Chart Recorder. Adjust the CALIBRATE switch on the Side Pack Assembly and the HI-LO switch on the Strip Chart Recorder to keep the peaks on-scale.

Blank Injections

Prior to the use of the OVA in the GC mode, a baseline condition must be established. Normally, a "blank" injection is performed, and the baseline is recorded. Note that if a chromatogram is to be introduced into a court of law as evidence, the blank injection is performed immediately prior to the sample injection. The blank is recorded and becomes a permanent part of the sample chromatogram.

There are several considerations in recording the blank. A blank is normally considered to be a sample of background or ambient air. Typical survey mode background measurements are around the 4 ppm level. For water sample analysis, a blank would be an injection of air taken from the headspace of a vial partially filled with distilled or organic-free water. The judgement of the analyst is the final criterion for what constitutes a blank injection, taking into account the nature of the sample and the final use of the data obtained from the chromatogram.

1.3.10 Maintenance

This section describes the routine maintenance tasks which can and should be carried out by the operator assigned to an OVA. As a minimum, routine maintenance should address the following elements of OVA care: proper charging of the battery pack, avoidance of restrictions in the air sampling line, checking for leaks in the air sampling line, and checking for leaks in the hydrogen supply system.

Charging of Battery Pack

The battery pack will be hooked up to the charging unit whenever the OVA is not in use. The charger can be left on indefinitely without damaging the batteries. If the batteries are not properly charged and the instrument is used continually, or a power switch is inadvertently left on, permanent damage to the battery pack may result. Approximately one hour of charging time is required for each hour of operation. Use of the Strip Chart Recorder reduces significantly the operating time which can be expected with a full charge.

Avoidance of Restrictions in Air Sampling Line

There are several points in the air sampling line of the OVA where filters have been placed to keep particulates from entering the instrument. In addition, there are two other filters within the instrument which may become blocked and restrict flow rate. The filters should be cleaned whenever the OVA has been operated for a period of time under dusty conditions and should be checked and cleaned whenever the SAMPLE FLOW RATE indicator on the instrument shows a decreased flow rate. The locations and cleaning procedures for these filters are summarized below (Refer to Figure 1-1 and Century Systems Operator's Manual for locations):

Primary Filter. This filter is located behind the sample inlet connector (Fitting Assembly) on the Side Pack Assembly and is removed for cleaning by using a thin-walled socket to unscrew the Fitting Assembly. The filter cup, "O" ring and loading spring will then come out as shown in the Side Pack Assembly drawing. The porous stainless filter cup can then be cleaned by blowing out or washing in a detergent, followed by thorough rinsing. The filter is then dried at 105°C in the oven provided

to each region. Reassemble in reverse order ensuring that the "O" ring seal on the Fitting Assembly is intact.

Particle Filters. A particle filter is located in each probe (pick-up) fixture. A filter must be in the sample line whenever the instrument is in use. The OVA uses a porous metal filter which can be cleaned like the primary filter.

Mixer/Burner Assembly Filter. Another porous metal particle filter is incorporated in the Mixer/Burner Assembly which screws into the Preamp Assembly. This filter is used as the sample mixer and inlet flame arrestor in the chamber. This filter should not become contaminated under normal conditions but can be cleaned or the assembly replaced if necessary.

Access to this filter for output surface cleaning is gained by simply unscrewing the exhaust port from the Preamp Assembly without removing the instrument from the case. The safety cover must be removed before the exhaust port is unscrewed. The Filter Assembly can be seen on the side of the chamber (Preamp Assembly) and can be scraped or cleaned with a small wire brush.

Exhaust Flame Arrestor. A porous metal flame arrestor is located in the exhaust port of the detector chamber (Preamp Assembly). It acts as a particle filter on the chamber output and restricts foreign matter from entering the chamber. This filter may be cleaned, if required, by removing the exhaust port from the Preamp Assembly. Clean the filter with a solvent or detergent but ensure that it is dry and any solvent completely baked out at 120°F before reinstalling.

Probe (Pickup). The pickup fixtures should be periodically cleaned with an air hose and/or detergent and water to eliminate foreign particulate matter. The fixture should be cleaned with detergent and baked at 105°C to eliminate any residual hydrocarbons.

Checking for Leaks in the Air Sampling System

Leaks in the air sampling pumping system can result in either dilution or loss of sample, causing low reading of vapor concentration and slow response time. The OVA is equipped with a flow gauge, which provides a method to check for air leaks. Assemble the pickup probe selected for use to the Readout Assembly and then position the Sidepack

vertically so that the flow gauge can be observed. Cover the end of the pickup probe with your finger and observe that the ball in the flow gauge goes to the bottom, indicating no air (if the ball has a slight chatter while on bottom, this is acceptable). Cover the center of the chamber exhaust port with your thumb and again observe the ball going to the bottom.

If the ball does not go to the bottom when the inlet is blocked, there is a leak in the system between the probe and the pump inlet or in the inlet check valve. To isolate the problem, remove parts one at a time and again block off the air inlet. Remove the pickup probe(s) and cover the air inlet at the Readout Assembly. If the ball goes to the bottom, check that the "readout to probe" seal washer is in place and replace the probes, holding them back against this seal while tightening the nut. Recheck, and if leakage is still present, it is probably in the probe (pickup fixture), which should be repaired or replaced.

If leakage is indicated as being past the readout handle when the connection to the Sidepack is tight, disconnect the sample line at the fitting on the Sidepack and cover this inlet with your finger. If the flow gauge ball goes to the bottom, the problem should be a leak in the Umbilical Cord/Readout Assembly, which should be investigated and repaired. There is also the possibility of a leaking check valve in the pump which would not show up on this test. If the leakage is not found in the Umbilical Cord, it is most likely in the pump check valve, which should be repaired or replaced at an authorized service facility.

Checking for Leaks in the Hydrogen Supply System

If after the unit is refilled with hydrogen, the pressure shown on the H₂ TANK PRESSURE indicator decreases rapidly (greater than 350 psig/hour), there is a significant leak in the H₂ supply system. These leaks may occur at any point in the system; however, there are points which are more likely to leak than others. A small amount of time spent checking these susceptible areas can help reduce down-time by providing service personnel with specific information. Also, there are suggestions which can help the OVA operator avoid causing these leaks in the first place.

The H₂ TANK VALVE, H₂ SUPPLY VALVE and REFILL VALVE are all constructed with Teflon washers which with time can "cold flow" (move with pressure) and allow hydrogen to leak. The life of these washers can be extended if the operator is careful to close these valves finger-tight. It is unnecessary to use a great amount of force on these valves. Leakage can be determined by using "Leak-Tec," "Snoop" or a soap solution around the valve stem.

If the source of the hydrogen supply system leak is one of these valves consult page 6 of the Century Systems Operator's Manual for instructions on tightening the compression nuts of the valves. If the source of the leak is not one of these valves, or if tightening of the valve compression nut does not correct the leakage problem, the instrument should be shipped to Foxboro-Wilkes for repair. (See Section 9 for address.)

1.4 TROUBLESHOOTING

It may be possible for the operator to identify and correct minor malfunctions or abnormal responses noted during initial startup and operation of the OVA. The corrections necessary may be simple adjustments and/or cleaning, or replacement of a part may be required. A troubleshooting chart is included in Appendix A, and a recommended spare parts list follows.

It is impossible and costly to maintain a large inventory of spare parts for the OVA. The following list includes those parts which are easily carried and replaced in the field. Regional operators are responsible for ordering and stocking these items:

<u>Item</u>	<u>Description</u>	<u>Century Systems Part Number</u>	<u>Quantity</u>
1	Igniter (glow plug)	510461-1	1
2	Filter cup (primary filter)	510318-1	1 pkg of 5
3	Particle filters	510116-1	2

1.5 SAFETY AND SHIPPING

The OVA is certified as intrinsically safe by the Factory Mutual (FM) Research Corporation for use in Class I, Division I, Groups A, B, C and D hazardous environments. Basically, this certification allows the instrument to be operated in areas where volatile, flammable organic compounds are present. If the oxygen concentration is reduced by displacement to below 16%, the FID will be extinguished. Any modification of the instrument will void the FM certification.

Hydrogen gas mixed with air is extremely flammable. Thus, the refilling procedure should be strictly adhered to, i.e., refilling should take place only in well-ventilated areas, away from sources of sparks, heat or flames. In addition, the unit's batteries must be recharged in a non-hazardous environment.

The U.S. Department of Transportation (DOT) has granted special permission to allow shipping of the OVA-128, when completely charged with hydrogen, on a passenger-carrying aircraft. The unit must be clearly labeled "HYDROGEN, FLAMMABLE GAS" with a DOT-approved label. In addition, a copy of the DOT letter authorizing shipment must accompany the OVA (See Appendix B). Note that if the unit does not contain hydrogen, it may be shipped without restriction.

1.6 CALIBRATION

Primary calibration of the OVA is accomplished at the factory by using methane in air samples of known concentration and making adjustments to four potentiometers located on the circuit board inside the instrument. This primary adjustment is relatively stable over time and should not concern field operators. The primary calibration may be checked during the annual factory maintenance procedure which will be required for each FIT unit. Maintenance schedules will be established by the FIT National Project Management Office (NPMO).

All FIT OVA's will be calibrated monthly to methane, and records kept on file to document the procedure. A 5 liter (l) gas sampling bag is filled with "clean" air. One cubic centimeter (cc) of a pure methane gas from a calibration cylinder is injected through the septum of the gas sampling bag. The sampling bag is then agitated to ensure complete diffusion of the sample. The concentration in parts per million (ppm)

(volume/volume) will be equal to the sample size in cc, divided by the volume of the bag in cc, times 1,000,000. Therefore,

$$\frac{1 \text{ cc}}{5000 \text{ cc}} \times 1,000,000 = 200 \text{ ppm}$$

Note: 1 liter = 1000 cc

The outlet of the sampling bag is connected to the air sampling line of the OVA. The GAS SELECT knob is then adjusted until the meter reading on the OVA is 200 ppm.

Since the instrument is calibrated to methane, the concentrations read for other compounds must be expressed as "methane equivalent" concentrations. It is possible to calibrate the instrument to other organic vapors by adjusting the GAS SELECT knob on the Sidepack control panel. However, this requires a supply of the gas of interest at a known concentration. Cylinders of various gases are commercially available and should be requested with the gas of interest and the balance as air. The calibration gas should be withdrawn from the cylinder and placed in a sample bag of known volume from which it may be drawn into the OVA. By making the appropriate calculations, samples of known concentration can be prepared. As the OVA draws in the sample, the GAS SELECT knob is turned until the calculated concentration of the sample is read on the meter. The instrument is now calibrated to read directly the concentration of the compound of interest.

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SECTION 2

INTRODUCTION TO THE hNu PHOTO-IONIZER

2.1 PERSONNEL

The hNu Photo-ionizer Model PI 101 is extremely simple to operate. After a few hours of training, virtually everyone on the FIT program can be taught to use the hNu efficiently. However, since the interpretation of its readings is often complex, personnel with specialized training and/or knowledge in its operation must be present to evaluate the data obtained from it.

2.2 THEORY OF OPERATION

The hNu is a portable, non-specific vapor/gas detector employing the principle of photoionization to detect a wide variety of chemical compounds, both organic and inorganic. The hNu contains a source of ultra-violet (UV) light within its sensor chamber. Ambient air is drawn into the chamber with the aid of a small fan. If the ionization potential (IP) of any molecule present in the ambient air is lower than the energy of the UV light source, that molecule will absorb a photon and become ionized. The following equation is the principal reaction:



where, RH = trace gas

$h\nu$ = A photon with an energy \geq IP of RH

The chamber contains a pair of electrodes with a positive potential applied to one electrode. The field thus created drives any ions formed by the absorption of UV light to the collector electrode, where the current (proportional to concentration) is measured.

The IP of the normal constituents of ambient air, i.e., O₂, N₂, CO, CO₂ and H₂O, are all higher than any available UV lamp source. Therefore, the instrument does not respond to those components.

The range of the instrument is from approximately 0.1 to 2000 ppm, depending on the span setting and the chemical nature of molecular species present within the sensor chamber.

2.3 INSTRUMENT OPERATION

2.3.1 Specifications

- o Range: 0.1 to 2000 ppm (benzene) Linear Range: 0.1 to 600 ppm
- o Sensitivity: 0 to 2 ppm, maximum for 100 division scale
- o Response Time: 3 seconds to 90% full scale
- o Operating Temperature: Ambient to 40°C.
- o Operating Humidity: To 95% relative humidity

2.3.2 Description

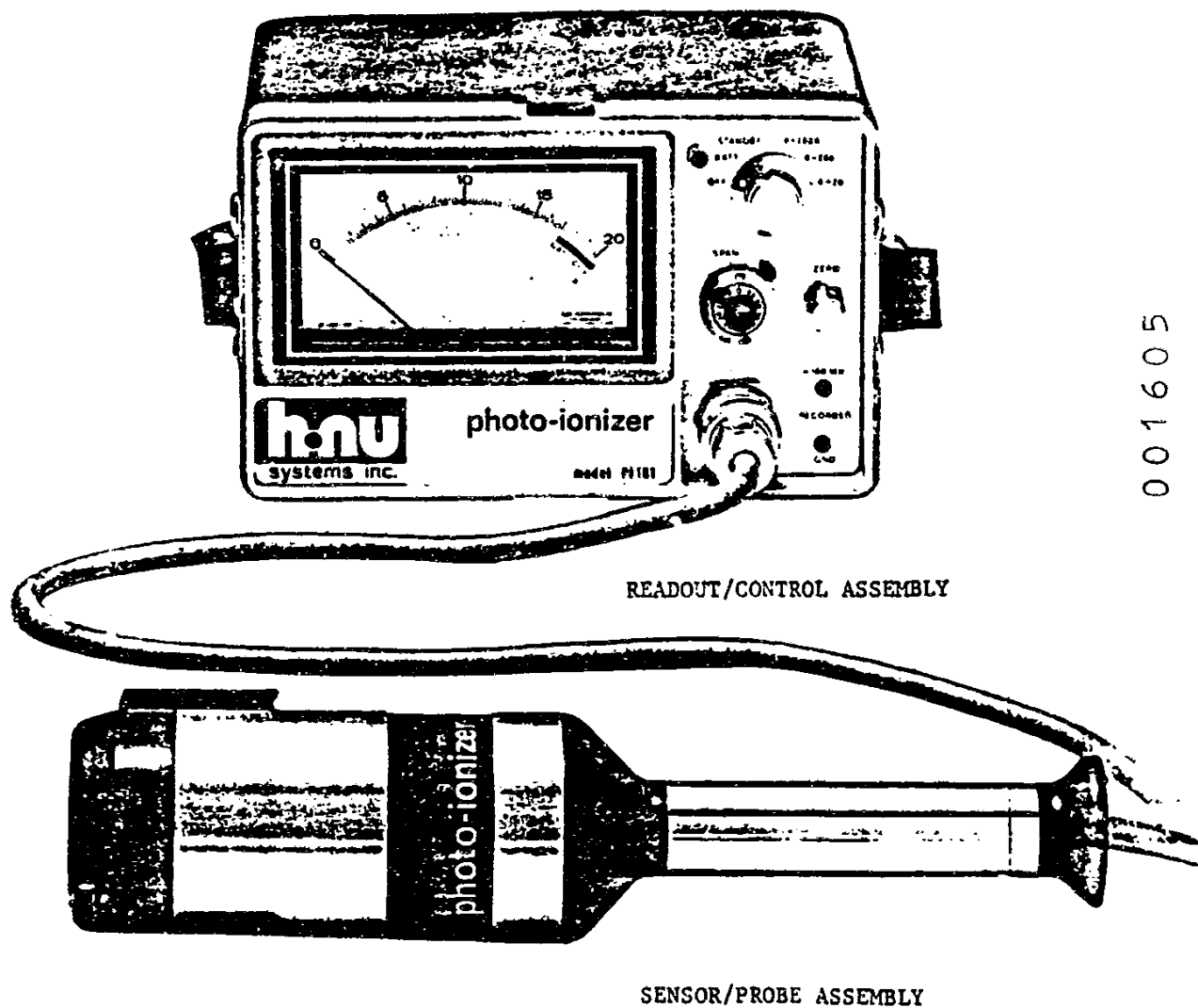
The unit consists of a Readout/Control Assembly and a Sensor/Probe. The Probe connects the Readout/Control Assembly via an electrical cord and 12-pin jack (front panel mounted). The Sensor/Probe can be disassembled and stored in the instrument's cover (See Figure 2-1).

2.3.3 Controls (refer to Figure 2-2)

Following are the controls on the Readout/Control Assembly:

- o Six-Position Function Switch: Selects functions according to the following:
 - o OFF: Complete power shutdown.
 - o BATT: Verifies the condition of the battery.
 - o STANDBY: Energizes entire unit except UV lamp. Used to zero instrument and to conserve power.
 - o Ranges 0 to 20, 0 to 200, 0 to 2000: Direct reading span of the meter face, in ppm.
- o ZERO Potentiometer: Electronically zeroes the instrument.
- o SPAN Potentiometer: Increases or decreases the sensitivity of the instrument with respect to full scale deflection. Used to calibrate instrument with specific span gas.

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Figure 2-1 hNu PORTABLE PHOTO-IONIZER, MODEL PI 101

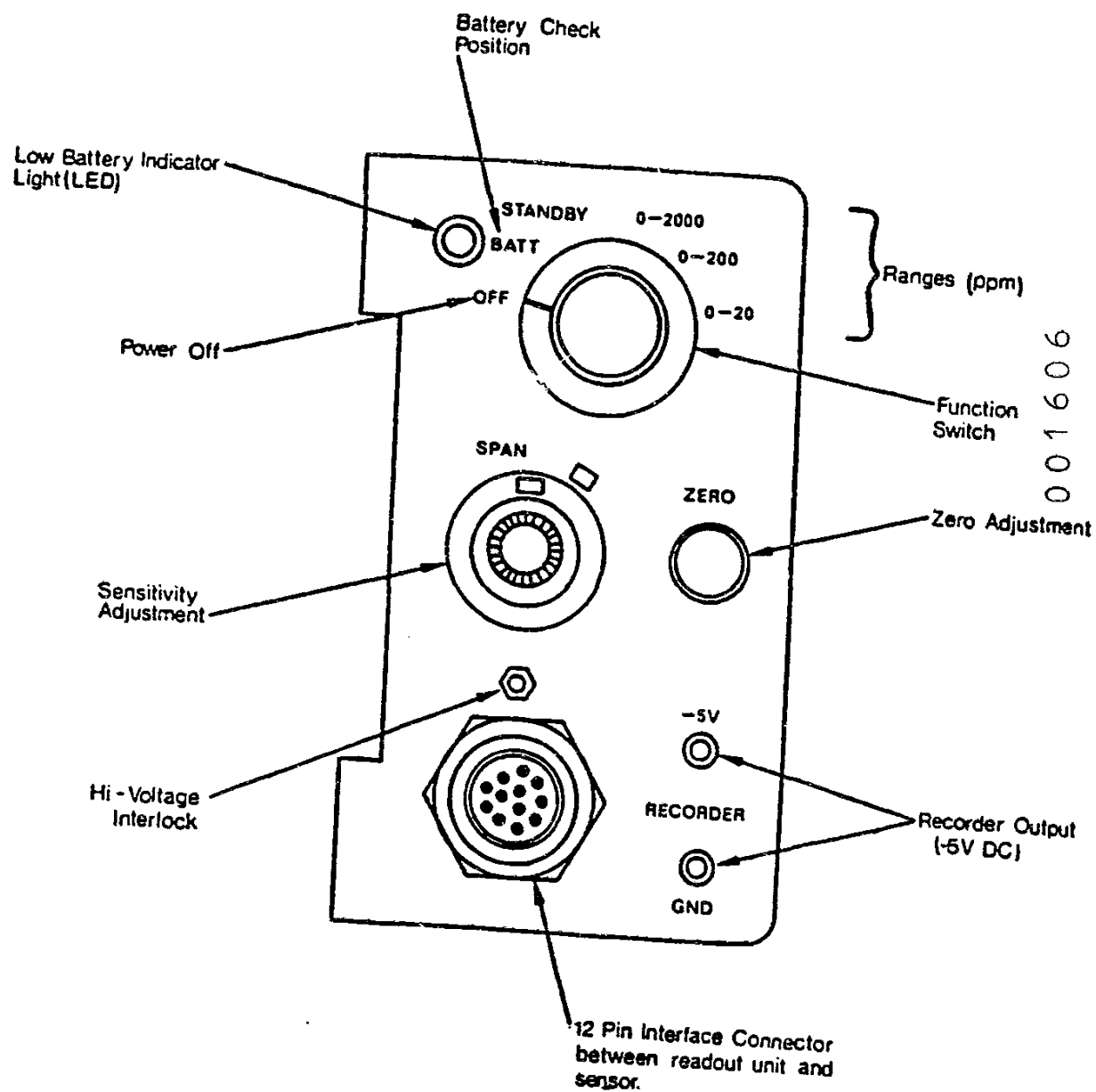


Figure 2-2 hNu CONTROL PANEL SCHEMATIC

- o RECORDER Output Jacks: 0 to -5 VDC signal output for recorder.
- o RECORDER Power Jack: Provides 12 VDC to drive recorder.

2.3.4 Battery Charging

To charge the battery, plug the charger into the jack on the side of the instrument case. The battery is fully charged after 14 hours of charging. Disconnect 120 VAC power before disconnecting the charger plug. A full charge provides about 10 continuous hours of operation. The instrument will always be left on charge when not in use.

The instrument is equipped with an automatic cut-off circuit which turns off the power if the battery voltage drops below 11 VDC. This prevents accidental damage to the electronics if it is inadvertently left on. Note that the unit can be operated with the charger on, unless it is in a hazardous (explosive) environment; however, it must be charged in a non-hazardous (non-explosive) area.

2.3.5 Operation

Start-up

The start-up procedure is as follows:

- (1) Connect Sensor Probe to Readout/Control Assembly.
- (2) Turn function switch to BATT and verify condition of the battery.
- (3) Turn function switch to STANDBY and utilizing ZERO potentiometer, set meter to zero. Hold Sensor/Probe next to your ear to verify that the fan is working.
- (4) Set SPAN control to 9.8 or to desired setting. (See Section 2.4 "Instrument Span.")
- (5) Select appropriate range. For most survey operations on the FIT Project, the setting used is 0 to 20 ppm. A violet-colored glow from the UV lamp source should be observable at the sample

inlet of the Probe/Sensor unit. (Avoid looking directly in since eye damage can result.)

- (6) Verify instrument operation. A convenient method is to gently blow into the Probe. There should be a 1 to 2 ppm deflection.

Shut-down

To shut the unit off:

- (1) Turn function switch to OFF.
- (2) Disconnect Sensor/Probe.

2.4 INSTRUMENT SPAN

The SPAN potentiometer increases or decreases the sensitivity of the instrument. (Counter-clockwise rotation increases the sensitivity.) At the recommended span setting of 9.8, it quantitatively responds to benzene, if benzene is the sole chemical species present. At this setting it will also respond, but not quantitatively, to all molecules with an IP of less than the energy of the UV lamp. The response to a molecule other than benzene (at the 9.8 setting) may be greater or less than that of benzene (on a volume/volume basis), depending on the molecule's type and structure. If a quantitative response to a specific chemical compound is desired, then the instrument span must be calibrated with that compound.

2.5 IONIZATION POTENTIALS

Since the hNu is used as both a safety and a survey device on the FIT Project, each unit is supplied with the 10.2 and the 11.7 ev UV sources. This allows the instrument to be used to detect a wide variety of chemical species. A list of the IP of many chemical compounds appears in Appendix C. Qualitative identification of compounds is not possible.

2.6 CALIBRATION

Primary calibration of the hNu is accomplished at the factory. For FIT applications, the calibration standard used is benzene and the SPAN potentiometer reading is 9.8. Primary calibration is normally stable for a long time. Routine calibration is most easily accomplished by using a

manufacturer-supplied cylinder of calibration gas (provided to each region). A sample of the calibration gas is drawn into the instrument and the SPAN potentiometer is adjusted until the instrument is reading the exact concentration of the calibration gas. Small deviations from the span setting over time are normal. Deviations of greater than $\pm 5\%$ indicate that the lamp window may need cleaning or, if that does not eliminate the deviation, the unit needs servicing. It is FIT Project policy that routine calibration be performed prior to each field use. This will also serve as an operational check to ensure that the instrument is responding properly. Records of routine calibration should be placed on file.

2.7 DATA

Any quantitative data obtained with the hNu must be reported as the equivalent value of its span gas. That is, with the span set to 9.8, a reading of 20 ppm would be reported as "20 ppm, benzene equivalent, span = 9.8." If a span setting of other than 9.8 is used, the data must be referenced to that particular span and/or calibration gas.

2.8 MAINTENANCE

The following subsections describe the minimum routine maintenance necessary. The instrument contains only one moving part and consumes no gases or reagents.

2.8.1 Cleaning UV Light Source Window

The only routine maintenance procedure specified by the manufacturer is cleaning the light source window every few weeks. This procedure is accomplished as follows:

- (1) Turn the function switch to the OFF position and disconnect the Sensor/Probe from the Readout/Control Unit.
- (2) Remove the exhaust screw found near the base of the probe. Grasp the end cap in one hand and the Probe shell in the other and gently pull to separate the end cap and lamp housing from the shell.

- (3) Loosen the screws on the top of the end cap and separate the end cap and ion chamber from the lamp and lamp housing. Care must be taken so that the ion chamber doesn't fall out of the end cap and the lamp doesn't slide out of the lamp housing. Turn the end cap over in your hand and tap on the top of it; the ion chamber should fall out in your hand.
- (4) Place one hand over the top of the lamp housing and tilt slightly; the light source will slide out of the housing. The lamp window may now be cleaned with the manufacturer-supplied cleaning compound.
- (5) Following the completion of cleaning, reassemble the unit by first sliding the lamp back into the lamp housing. Then place the ion chamber on top of the lamp housing, checking to make sure that the contacts are properly aligned.
- (6) Place the end cap on top of the ion chamber and replace the two screws. The screws should be tightened only enough to seal the "O" ring. DO NOT OVERTIGHTEN. Line up the pins on the base of the lamp housing with pins inside the probe shell. Gently slide the housing assembly into the shell; it only fits one way.
- (7) Replace the exhaust screw.

Figure 2-3 shows the component parts of the Probe Assembly.

2.8.2 "Fogging" of UV Light Source Window

During cold weather operations, condensation may form on the UV light source window, resulting in reduced levels of response. Field operators can follow the procedure outlined in Section 2.8.1 for removing the lamp to clear it of condensation. Consideration should also be given to more frequent cleaning when the instrument is used under very dusty conditions, such as on a landfill in dry weather.

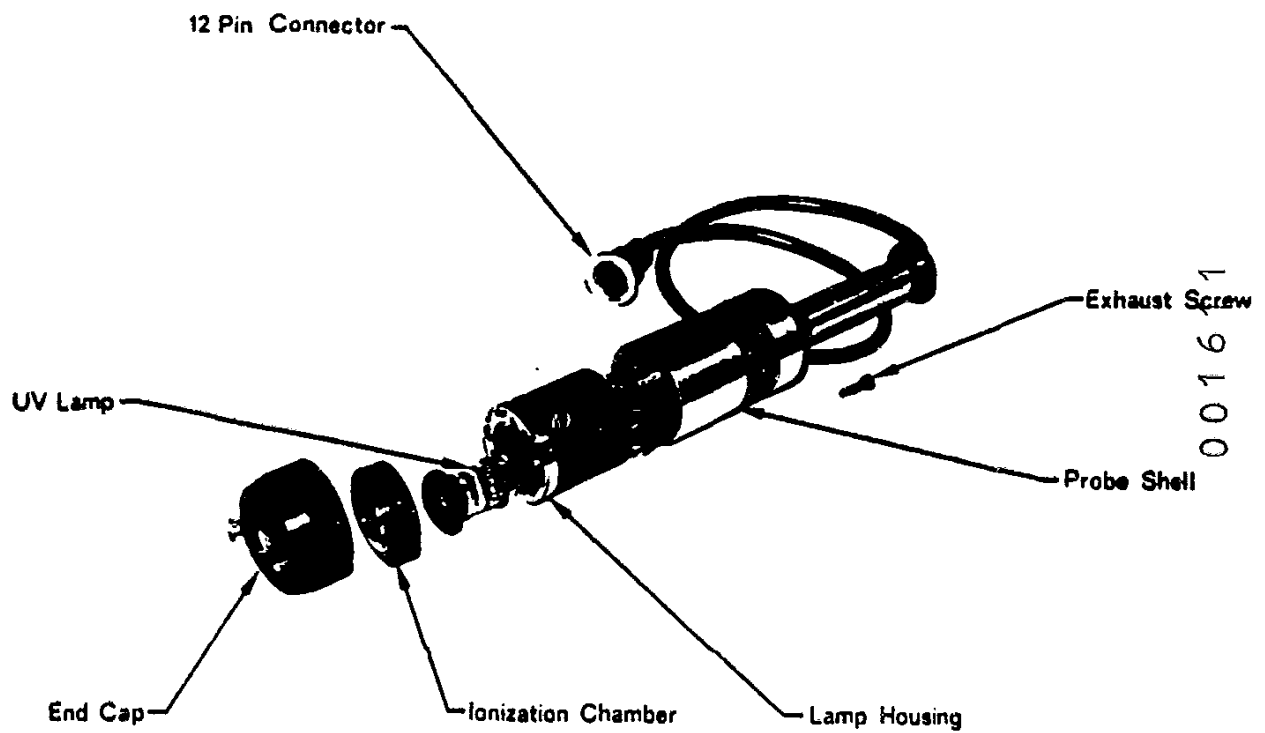


Figure 2-3 COMPONENT PARTS OF THE hNu PROBE ASSEMBLY

2.9 TROUBLESHOOTING

If any malfunctions are noted during the start-up and operational check of the hNu prior to field use, refer to Appendix D for some basic troubleshooting guidance. Any problems which cannot be resolved quickly by the field operator should be referred to the factory for correction. (See the resource list at the end of the manual for the address and telephone number.)

2.10 SAFETY AND SHIPPING

The hNu can be carried on any aircraft as luggage; however, do not check it unless it has been carefully packaged. Commercial airlines will not insure it unless it is shipped in its original container.

The hNu has Factory Mutual (FM) Certification for operation in Class 1, Division 2 of the National Electrical Code. Therefore, the hNu should not be used in environments which are above 10% of the lower explosive limit (LEL), since the circuitry in the probe assembly is relatively open and could be an ignition source. This action level for % of the LEL agrees with that for site evacuation during FIT operations.

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SECTION 3

GENERAL FIELD APPLICATIONS

This section describes the application of the OVA and the hNu for general field purposes. The types of application described would typically be associated with a FIT initial involvement with a site. The use of the OVA and hNu for more specialized applications such as sample screening and use during hydrogeologic investigations are described in Sections 4 and 5.

3.1 AMBIENT AIR CHARACTERIZATION

A basic application of the OVA and hNu is in the characterization of the air quality at a site, which should be a primary objective for an initial site entry operation. The OVA and hNu can be used in tandem to accomplish this task, or either may be used alone depending upon the availability of equipment. The data obtained from a site air characterization study can be integrated with other available data to assist FIT personnel to evaluate whether the air quality at a site may be endangering the surrounding population and to determine the appropriate level of respiratory protection for subsequent site operations.

The OVA or hNu operator, or both, are included as part of the initial site entry team. The other members of the initial site entry team are responsible for operating the characterization equipment which is standard for FIT initial site entry, i.e., oxygen meter, explosimeter, radiation survey equipment, and Draeger tubes. The OVA and hNu do not replace any of these pieces of equipment. Once a thorough site characterization has been performed, it may be possible and desirable to eliminate the use of all but the OVA or hNu, depending on site activities.

3.1.1 OVA Use for Ambient Air Characterization Preparation

The OVA should be operating in the survey mode prior to site entry. The Side Pack Assembly can be protected from contamination by using a clear plastic bag. The sampling line/umbilical cord and Readout Assembly can similarly be protected by wrapping in clear plastic. The

wide-area extension probe should be used and can also be plastic-wrapped. Before anyone crosses the hot line, a background reading should be taken and recorded. (NOTE: At this point it is imperative that the OVA operator checks to see that the SAMPLE INJECT VALVE is in the UP position. If the valve is in the DOWN position, air will be scrubbed through the activated charcoal filter.)

Operation

The site characterization is carried out with the wide-area probe being continually moved around in horizontal and vertical arcs as the operator is walking. The times one (X1) scale should be used initially, and sensitivity can be reduced as conditions dictate. Conditions such as wind direction/speed and air temperature, which affect the presence or movement of air contaminants, should be noted. It is also suggested that a sketch of the site layout be carried so that OVA readings can be noted on it. Special attention should be given to those areas which might be sources of vapors or gases. These would include stored drums, tanks, lagoons, etc.

Methane vs. Non-methane Organics

The presence of methane at landfill sites may result in significant OVA response. In the absence of an hNu, which would not respond to methane, the following simple operation with the OVA can be used to determine whether the response is due to methane or volatile organics. (Figure 3-1 summarizes this discussion.)

- (1) Hold the probe in the area where a response has been registered.
- (2) When a fairly constant (5 to 10 seconds) reading is observed, depress the SAMPLE INJECT VALVE. This introduces a 250 ul aliquot of the ambient air to the GC column and directs all subsequent ambient air through the activated charcoal filter. If methane is present, two responses will be seen. The needle on the Probe Assembly meter will deflect quickly upscale, since the methane elutes within 1 to 2 seconds. Secondly, the con-

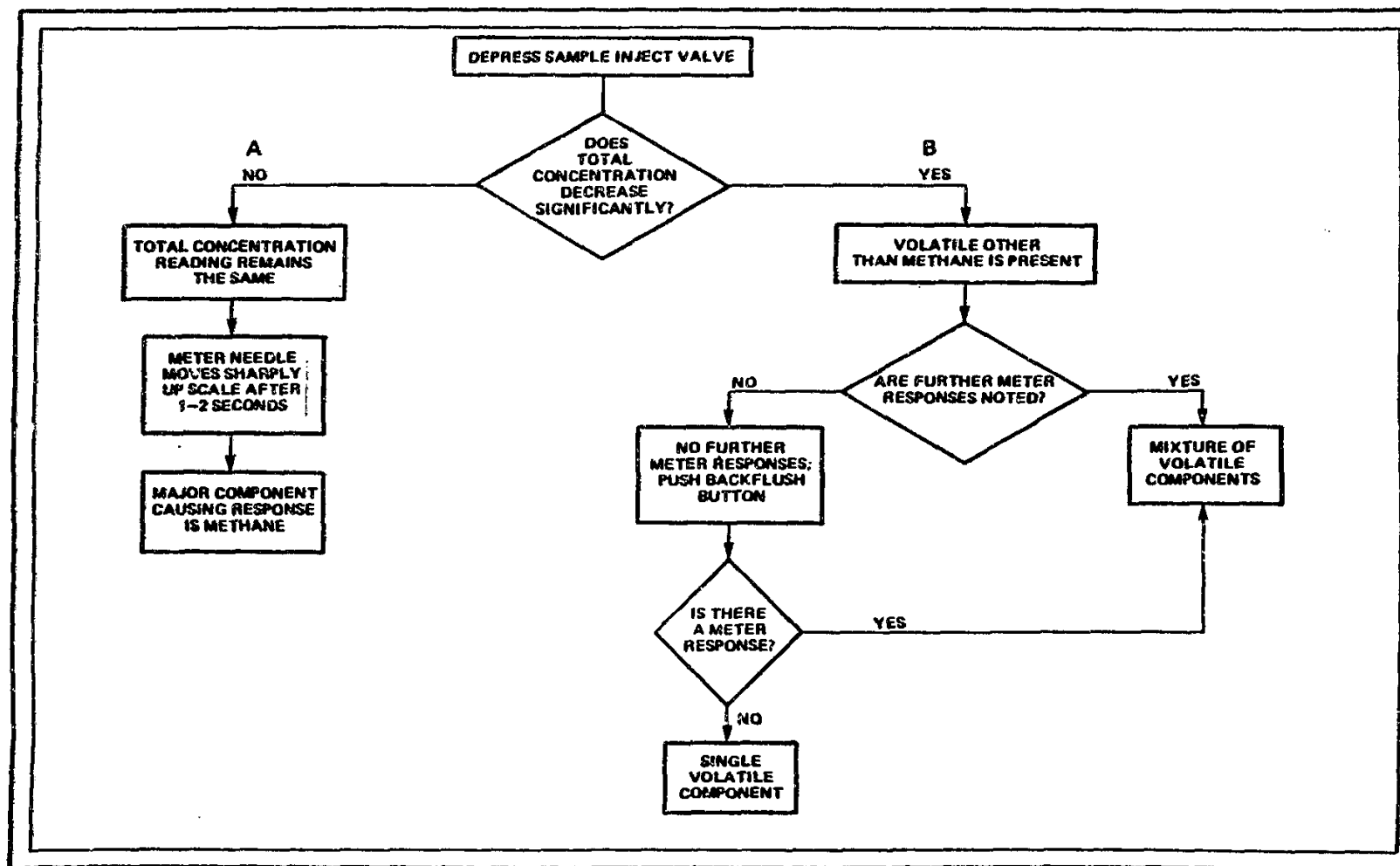


Figure 3-1 DETERMINATION OF METHANE VERSUS NON-METHANE ORGANICS (A) AND SINGLE VERSUS MULTI-COMPONENT ATMOSPHERES (B)

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centration before and after activating the SAMPLE INJECT VALVE will not be that much different if methane is causing the response, since the methane will not be scrubbed out by the activated charcoal. If heavier volatile organics are the major sources of the response, there will be a significant decrease in the concentration reading after the SAMPLE INJECT VALVE is depressed, since those volatiles will be scrubbed out by the activated charcoal. Additionally, as the compounds elute from the GC column, an upscale meter deflection will occur each time a compound reaches the detector. Observation of this response can also help the operator determine whether the volatile contaminants are present as a mixture or as a single component.

- (3) After several minutes have elapsed, the BACKFLUSH VALVE should be activated. Any significant upscale deflection of the meter needle is indicative of the presence of an additional component which has not yet eluted from the column. Note that a slight upscale motion occurs upon activation of the valve. This information would be integrated with the other data gathered in the course of evaluating the site's air quality.
- (4) Following several minutes of backflush, the SAMPLE INJECT VALVE should be returned to the UP position before taking readings at a new location. It is not necessary to reactivate the BACKFLUSH VALVE at this point.

Decontamination

During the on-site characterization work, all care must be taken to avoid bringing the OVA into direct contact with contaminants. When on-site work is completed, any disposable material used to protect the instrument should be removed and disposed of with other items from the field operation. A plastic sheet should be provided at the hot line for an equipment drop.

Data Evaluation

The data obtained from an initial air characterization must be in-

corporated with all other available information and observations obtained during the initial site entry. If no readings above background were recorded, there must be information or observations which can rule out the presence of non-detectable vapors or gases (i.e., inorganics) before a reduction in the level of respiratory protection is allowable. If significant readings attributable to non-methane organics were recorded, further characterization must be undertaken before air-purifying respirators may be selected for respiratory protection over self-contained breathing apparatus (SCBA). Sections 5 and 6 provide detail for further site air quality characterization work. Caution: It should be noted that the air quality of a site, as determined by an initial site entry walk-through, becomes altered by a variety of activities or conditions which may induce or accelerate the volatilization of potentially hazardous substances. These activities or conditions include temperature changes, excavation work, soil boring work and other types of remedial work. Further monitoring will be necessary during these activities in order to determine air quality.

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Limitations of OVA Use for Ambient Air Characterization

Use of the OVA for site ambient air characterization has the following limitations:

- o The lower limit of detection for survey mode operations is 1 ppm in air. Some air contaminants have lower odor thresholds than 1 ppm (e.g., H₂S has an odor threshold of 5 ppb).
- o In the survey mode, responses are read as total organic vapor concentrations. Further work is necessary before decisions can be made about the level of respiratory protection (see Sections 4 and 5).
- o The hydrogen flame in the OVA FID can operate at an oxygen concentration of 16.0%. Therefore, flame-out of the FID due to oxygen depletion will not give the same indication of oxygen concentration that an oxygen meter will.

- o The OVA will not indicate the presence of inorganic species.
- o A relative humidity greater than 95% will cause inaccurate and unstable responses.
- o A temperature less than 40°F will cause slow and poor responses.

3.1.2 Use of the hNu for Ambient Air Characterization

Preparation

The hNu can be prepared for on-site air characterization by first starting it up (Section 2.3.5) and then taking steps to protect it from contamination by bagging the Readout/Control Assembly in plastic, wrapping the power cord in plastic, and bagging the Sensor/Probe Assembly. Care should be taken to avoid covering the air sample inlet. Before anyone crosses the hot line, a background reading should be taken and recorded. Initial operation should take place with the function switch set on the 0 to 20 ppm range.

Operation

On-site air characterization is carried out in a manner similar to that described above for the OVA. The function switch should remain set on the 0 to 20 ppm range, with changes made to the less sensitive ranges as site conditions dictate.

Use of the 11.7 eV and 10.2 eV Sensor/Probe Assemblies

The initial survey should be made with the 10.2 eV Sensor/Probe Assembly. Although the 11.7 eV assembly detects a greater variety of compounds, its operating life is considerably less than that of the 10.2 eV. If significant readings are noted at various site locations, the 10.2 eV unit can be exchanged at the hot line for the 11.7 eV unit. (Note: Turn the instrument OFF when changing Sensor/Probe Assemblies.) Second readings can then be made where response to the 10.2 eV unit occurred.

If significant differences between the two readings are noted, Appendix C can be consulted for the possibility of ruling out the presence or absence of certain groups of contaminants on the basis of ionization potential. Qualitative identification is not possible.

The fact that neither the 10.2 nor 11.7 eV Sensor/Probe Assembly will respond to methane is helpful at a landfill site since the hNu will register response only to those compounds of greater interest. If an OVA is used in tandem, the difference in response between it and the hNu can help to approximate total concentrations of methane and non-methane organics. Additional information can be interpreted from the knowledge that the hNu may also respond to certain inorganic vapors or gases.

Decontamination

Decontamination procedures are the same as outlined above for the OVA.

Data Evaluation

As is the case with evaluating data obtained from an initial site air characterization using the OVA, the hNu readings must be integrated with other available data. Of possible significance is the fact that the hNu responds to inorganic species as well as organic.

Limitations of hNu Use for Ambient Air Characterization

Use of the hNu for site ambient air characterization has the following limitations:

- o The lower limit of detection for the instrument is approximately 1 ppm. Some air contaminants have lower odor thresholds than 1 ppm.
- o Further site work is necessary before decisions can be made about the level of respiratory protection.
- o Since the hNu operates on the principle of photoionization, variations in oxygen concentrations will not affect detector operations.
- o Since the hNu does not respond to methane, an explosimeter and oxygen meter should be used on initial site entry or in areas

where potentially explosive concentrations of methane could accumulate.

- o The "capture velocity" of the hNu is less than that of the OVA. This means that the air sample inlet of the Sensor/Probe Assembly must be closer to a gas/vapor source than the OVA probe. Also, air from a smaller area is drawn in by the hNu. The use of accessory pumps to increase the capture velocity is currently being evaluated.
- o When the air temperature is below 40°F, fogging of the UV lamp source may occur, reducing response (See Section 2.8.2).
- o A relative humidity higher than 95% will cause inaccurate and unstable responses.

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3.2 IDENTIFICATION OF POTENTIAL SAMPLING POINTS

Both the OVA and the hNu can be of value in helping to locate containers and/or areas of a site which might produce samples having significant concentrations of contaminants. The types of contaminants detected in this application are generally volatile organic compounds, unless the hNu is being used to detect an inorganic vapor or gas. This type of activity should follow the initial site entry/ambient air characterization operations described in Section 3.1. Additionally, the level of respiratory and personnel protection used for identifying potential sampling points should be carefully evaluated since the potential for exposure to contaminants is greater.

3.2.1 Containers

The sampling probe of either the OVA or hNu can be inserted into the headspace of any open containers, such as drums or tanks. This operation should be performed with the hNu function switch set on "0 to 2000." This may provide an indication that the contents are volatile, depending on the length of time that the containers have been exposed to weathering, dilution, etc.

CAUTION: Avoid inadvertent immersion of the probe into the container contents. Should this happen, shut down the instrument immediately and take it off-site for immediate cleaning.

3.2.2 Soil

A "quick-and-dirty" identification of potential subsurface soil sampling points can be made by using a shovel to dig shallow holes and placing the probe of the hNu or OVA into the hole to detect the presence of spilled, leaked, or discharged volatile organics. A scaled-up version of this technique could involve the use of a backhoe to excavate test pits. This technique is a relatively fast and inexpensive way to track subsurface contaminant migration without actually installing bore holes and wells.

An approach which is in the prototype phase of development is to drive a hollow soil probe into the ground, use a portable vacuum pump to withdraw vapor from the probe and take a reading with the hNu or OVA. In this way, it would be possible to track shallow subsurface contamination with minimal disturbance and cost.

CAUTION: Any subsurface exploration should be preceded by a determination that buried hazards do not exist. Care should also be taken to avoid clogging the instruments' sampling probes.

3.2.3 Air

An initial site entry/ambient air characterization should have identified any areas on the site where significant concentrations of contaminants were noted. This information can provide the basis for a more intensive air sampling program. "Hot spots" previously identified may be expedient locations from which real-time or integrated air samples may be taken. (Meteorological and other pertinent data should be evaluated before initiating an air sampling program. Sections 4 and 5 provide further guidance.)

3.2.4 Water

See Section 4 for information on locating potential water sampling points.

3.3 RESPIRATORY PROTECTION

One of the objectives of the ambient air characterization/initial site entry procedure is to obtain information to help in evaluating the level of respiratory protection for subsequent site operations. The OVA/hNu readings recorded during the initial air characterization are TOTAL vapor/gas concentrations and, unless further work is done, do not provide the qualitative/quantitative data which are required by regulatory agencies such as the Occupational Safety and Health Administration (OSHA) and National Institute for Occupational Safety and Health (NIOSH) for setting levels of respiratory protection. Therefore, it is impossible to safely or legally establish "action levels" for respiratory protection based upon OVA/hNu readings.

Even if OVA/hNu readings on-site do not exceed the recorded ambient background level, other site information must also point to the absence of a respiratory hazard before a decision can be made. Further, if subsequent site activity such as drum sampling or removal or excavation may alter the air quality, additional monitoring and respiratory protection will be required.

Thus, if it is determined that a respiratory hazard exists at a site, an SCBA must be worn. Air-purifying respirators are permitted only when the contaminant identities and concentrations are known, continued monitoring takes place, and sufficient oxygen levels are present (>19.5%).

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SECTION 4

GAS CHROMATOGRAPHY

4.1 GENERAL

This section assumes that the reader has a detailed understanding of gas chromatography. It is intended to cover the aspects of gas chromatography that apply directly to the FIT program. For an excellent reference, see Basic Gas Chromatography by J. M. McNair and E. J. Bonelli, published by Varian Aerograph.

4.2 ACCESSORIES

Table 4-1 contains a list of accessories considered to be basic for conducting a GC analysis. Additional equipment may be necessary for specific applications. More detailed guidance on analytical standards is found in Section 6; additional information is found in Appendix E.

4.3 QUALITATIVE ANALYSIS

Unknown chemical compounds can be identified by gas chromatography by a comparison of their retention times with known compounds. The retention time is generally defined as that time from injection to peak maxima. With proper flow and temperature control, it can be reproduced to 1% under laboratory conditions. Several compounds may have close, or even identical, retention times, but each compound has only one specific retention time under a given set of conditions. The presence of other components does not effect a compound's retention time.

A standard set of reference compounds is being prepared for use in the FIT Project (See Section 6). Their retention times must be established on each column prior to a field operation. Since the columns are not temperature-controlled, their retention times will vary considerably from the laboratory to the field. However, by keeping track of the temperature, plots can be established relating retention time to temperature. With experience, the relationship of retention time to temperature should become fairly well understood.

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TABLE 4-1
ACCESSORIES NEEDED FOR GC ANALYSIS

Quantity	Description	Product Number*
1	Isothermal Column: G-24	--
1	Isothermal Column: T6 (PIP Assembly)	511805-1
1	Isothermal Column: T-12	--
1	Teflon k Tape with dispenser	HGC-070
2	Septums (12)	HGC-125
1	1/8" plastic column caps (250)	HGC-163
2	500 ul syringe (Syringe model #1750)	HCS-204
1	250 ul syringe (Syringe model #1725)	HCS-203
2	10 ul syringe (Syringe model # 701)	HCS-001
1	5 ml syringe (Syringe model #1005)	HCS-020
1	10 ml syringe (Syringe model #1010)	HCS-021
1	5 liter Mylar bag	HGC-279
1	Charcoal Type GI 1-lb container	--
1	Chart Paper (Linear): Type "WA" (includes 6 rolls)	CSC-008

*From Foxboro/Wilkes (Analabs-Century Systems) catalogue.

4.4 QUANTITATIVE ANALYSIS

The OVA is calibrated to respond quantitatively to methane. In order to perform quantitative analysis, reference standards must be prepared for each compound of interest (See Section 6). By comparing the peak height of the standard, it is possible to establish fairly reliable quantitative data in the field. More time-consuming techniques, such as the analysis of the area under the peak generated by the compound, are not field expedient. As in the case of qualitative analysis with the OVA, the quantitative data should not be the final word. These data should be used to assist in further work and can be incorporated into decision criteria used to evaluate a scope of work.

4.5 COLUMN SELECTION

There are three basic columns available from Foxboro-Wilkes (Analabs):

"T" - 1% 1,2,3 Tris (2-cyanoethoxy) propane (also known as TCEP) on Chromosorb W HP, 60/80 mesh.

"G" - 10% OV-101 on chromosorb WAW - DMCS treated 60/80 mesh.

"B" - 3% Diisodecyl Phthalate on Chromosorb WAW 60/80 mesh.

The columns are available in 8-, 12-, and 24-inch lengths. The "T" column is a high polarity column, "G" is medium polarity, and "B" is low polarity. In order to have an efficient separation, the column should have a polarity similar to that of the chemical composition of the mixture being separated. Table 4-2 lists the approximate polarity of several different classes of chemical compounds.

Obviously, there is no one column that will separate all chemical compounds. The problem is complicated by the fact that many of the mixtures encountered on hazardous waste sites are composed of compounds of widely different polarities. For general-purpose separations, the "G" column is most useful. Field experience has also confirmed the usefulness of the "T" column.

TABLE 4-2

APPROXIMATE POLARITY OF SEVERAL CLASSES OF COMPOUNDS

Group I: High Polarity

Water	Primary amines
Glycol, Glycerol, etc.	Secondary amines
Hydroxy acids	Oximes
Polyphenols	Nitro compounds (-H)
Dibasic acids	Nitriles (-H)
Alcohols	NH ₃ , HF, N ₂ H ₄ , HCN
Fatty acids	
Phenols	

Group II: Intermediate Polarity

Ethers	Ketones
Aldehydes	Esters
Tertiary amines	Nitro compounds
Nitriles	

Group III: Low Polarity

Chlorinated hydrocarbons
Aromatic hydrocarbons
Olefinic hydrocarbons

Group IV: Non-Polar

Saturated hydrocarbons
CS₂
Mercaptans
Sulfides
CCl₄

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4.6 SYRINGE TECHNIQUES

Sloppy syringe technique can negate the results of the most careful GC analysis. Thus, before a gas-tight syringe is used, it must be thoroughly checked for leaks and proper flow:

- (1) Leak-check the syringe by inserting the needle into an old septum and depressing the plunger. There should be a pressure build-up.
- (2) Check for flow by placing the needle tip in a small amount of deionized water and depressing the plunger. A flow of bubbles should be observed.

Gas-tight syringes can easily become contaminated. For critical injections, particularly if they are to be used as evidence in litigation, a blank must be performed to establish if the syringe is "clean." Blanks are not as important for routine analysis, for determination of retention times, etc. However, syringe contamination is one of the most common sources of errors in GC analysis.

4.6.1 Injection Method

Hold the syringe in two hands, using one to guide the needle into the septum and the other to provide force to pierce the septum and to prevent the plunger from being forced out by the pressure from the GC. Insert the needle through the septum as far into the injection port as possible, swiftly and smoothly depress the plunger, hesitate one second, and withdraw the needle. Operators should practice on old septa to develop the technique.

4.6.2 Syringe Cleaning Procedure

If a gas-tight syringe becomes contaminated, the easiest method of cleaning is to bake it in the oven at 105°C overnight. It may be possible to clean the syringe by removing the plunger, inserting the needle into the injection port, and allowing carrier gas to flow through it for several minutes. See Section 6.2 for instructions on checking syringe cleanliness.

4.7 RETENTION TIMES

Appendix F contains a selected list of average retention times for various chemical compounds. All temperatures are listed in °C, and all times are in seconds.

4.8 FLOW RATE AND TEMPERATURE

For the most reproducible GC analysis, the flow rate of carrier gas and the temperature of the column should be noted. The flow indicator on the OVA Sidepack Assembly provides a relative indication of flow rate, which should remain constant over the time of the analyses. Appreciable changes in flow rate may be dealt with by consulting Section 1.3.9. The temperature of the column should be monitored continuously. Temperature uniformity can be enhanced by wrapping the column in aluminum foil and keeping the OVA out of direct sunlight.

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SECTION 5

SPECIAL APPLICATIONS OF THE OVA AND hNu

5.1 INTRODUCTION

Section 3 described general applications for use of the OVA and hNu. Most of the regional FITs have or will have the opportunity for more specialized use of the OVA and/or hNu. The special applications may include monitoring for vapors or gases and/or actual field analysis.

5.2 MONITORING

The use of the OVA and hNu for monitoring purposes involves simply focusing the site ambient air characterization process on a specific activity. The objective is to ensure that the personnel involved in the activity are not endangered by the changes in air quality caused by the activity. The following subsections address some specific monitoring applications. FIT personnel who are trained OVA/hNu operators are encouraged to expand these monitoring applications on the basis of personal field experience.

5.2.1 Hydrogeologic Investigations

At sites where volatile organic wastes are buried, the installation of bore holes and monitoring wells can expose personnel to a respiratory hazard. Often, the preliminary air characterization of the site and other data, such as the presence or absence of wastes on the site surface, may indicate that there is no respiratory hazard. However, the drill bit may penetrate contaminant-saturated soils or highly contaminated groundwater. Depending upon the temperature and other conditions, dangerous concentrations of volatiles may be present in the area immediately above the bore hole. The personnel in the immediate vicinity of the bore hole are at greatest risk. The OVA in the survey mode or the hNu may be used to monitor the potential for exposure by periodically placing the sampling probe of the instrument directly at the top of the bore hole (drive casing). As is the case with ambient air monitoring, there can be no "action levels" since the readings will be total concentrations. Project personnel must use their best professional judgement,

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incorporating other conditions, in order to decide whether the use of SCBA is warranted or whether engineering controls such as fans can be used to reduce the possibility of exposure.

The hNu is better suited for this type of monitoring for several reasons. First, it will not respond to naturally occurring methane. Second, it is less cumbersome and readily operated by a wider variety of personnel. Third, if an hNu and OVA are available, the hNu can be used to monitor the drilling operation while the OVA is being used in an on-location laboratory for field analysis. The probe of the OVA or hNu can also be used in the drilling area to "sniff" soil core samples as they are brought up in a split-spoon sampler. Care should be taken to identify occasional readings caused by exhaust gases from the drilling rig.

5.2.2 Remedial Response

A variety of remedial response activities can result in altering ambient air quality. Use of the OVA and hNu to monitor air quality can provide real-time data which can be used to evaluate respiratory protection needs. The following list is representative of the types of work which, if carried out at sites where volatile organics were the principal compounds, might require OVA or hNu monitoring:

- o Overpacking or pump transfer of leaking drums
- o Transfer of individual drum contents to bulk tanks for removal and disposal
- o Staging/containment operations of leaking drums
- o Excavation of buried leaking drums
- o Excavation of contaminated soil for removal and disposal
- o Emergency or planned containment operations, e.g., construction of leachate collection ditches
- o Emergency treatment operations, e.g., air-stripping of contaminated groundwater

- o Emergency/on-site disposal operations, e.g., on-site incineration, detonation where risk/cost prohibits off-site removal

5.3 FIELD ANALYSIS

The OVA in the GC mode of operation and, to a limited degree, the hNu can be used in the field to perform preliminary analyses of various air, water, or soil samples. The data generated can be of significant value in making field decisions, responding rapidly to an immediate threat, reducing analytical costs, and selecting future sampling locations. The following is a list of several of these field analytical applications:

- o Preliminary volatile organic analyses of soil, surface water, or groundwater samples obtained during site inspections
- o Analysis of soil core samples for volatile organics during monitoring well installations
- o Analysis of drilling wash water samples during monitoring well installation to prevent accidental contamination of clean wells
- o Preliminary analysis of air samples to establish best locations for integrated sample stations
- o Rapid preliminary analysis of tap water samples for volatile organics

Once samples have been obtained, the field analytical procedure is essentially common for all types of sample media. Section 6 details the procedures for preliminary field analysis, or, sample screening.

SECTION 6

SAMPLE SCREENING

6.1 INTRODUCTION

Preliminary field analysis for volatile organic compounds, or sample screening, can expand the capabilities of a FIT investigation. A large number of sites investigated by FIT have involved the disposal of wastes containing volatile organic compounds. This presents the opportunity to use the OVA, and in some cases the hNu, to generate data which can facilitate an investigation by providing timely information, helping to focus sampling efforts on appropriate site areas, and reducing field and analytical costs.

Sample screening can be carried out virtually anywhere, including the back of a FIT van, a motel room, or the office. All that is required is a small table (a folding table and chair in the back of a FIT van makes an excellent field laboratory) and the appropriate accessories to support an OVA GC analysis. The following sections discuss specific aspects of the sample screening process using the OVA. Section 6.5 describes the process of using the hNu.

6.2 WATER SAMPLES

Water samples for volatile organic screening are collected in 40 to 44 milliliter (ml) septum vials. Samples can be collected leaving an approximate 25% headspace, or the vials may be completely filled as for sample collection for laboratory volatile analysis. (Note: For all OVA work, injected samples must be either in the gas or vapor state.) Starting with a completely filled vial will allow a more precise quantitative analysis, as a syringe can be inserted through the septum of the vial to withdraw exactly 25% of the total volume, giving a 25% headspace from which to draw vapor for analysis. (Note: All samples injected in the OVA must be either gas or vapor.) A syringe needle must also be inserted through the septum at the time of withdrawal to allow air to enter the headspace as water from the full vial is drawn out. The analysis of the samples can be described as four phases: total volatile screening, GC screening, compound identification, and quantitation.

6.2.1 Total Volatile Screening

This phase allows an operator to rapidly determine whether any volatiles are present in a large number of samples. The elements of the process are:

- (1) Water samples with 25% headspace (may be approximate or determined by syringe, as previously described) are allowed to reach the surrounding air temperature (back of van, office, etc.). A water bath may be used to accelerate the process, if needed.
- (2) Each sample is shaken vigorously for about 120 seconds to drive volatiles from the water into the air headspace above the water.
- (3) The OVA is started up and allowed to run for several minutes. The column temperature should be given time to equilibrate with the surrounding temperature.
- (4) For this process, the BACKFLUSH VALVE must be in the DOWN position. The SAMPLE INJECT valve may be in the UP position if the ambient air is relatively clean or in the DOWN position if there might be interfering volatiles present (e.g., from drill rig exhaust) which will be scrubbed by the activated charcoal filter with the valve in the DOWN position.
- (5) A gas-tight syringe is flushed several times in "clean" air. A check for syringe cleanliness can be made by inserting the syringe into the injection port of the OVA and slowly depressing the syringe plunger while watching the read-out meter. Note that any injections made with the BACKFLUSH VALVE in the DOWN position will go directly to the FID without going through the column. If the read-out meter responds while the blank injection is being made, the syringe is dirty and should be flushed again; a second blank injection should then be made. If the syringe is heavily contaminated, it should be cleaned as described in Section 4.6.

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- (6) The gas-tight syringe is used to withdraw vapor from the headspace of the sample. The amount of vapor withdrawn is dependent on the anticipated concentration of contaminants. For example, 1.0 ml would be a recommended starting volume for a drinking water sample, whereas 250 ul would be a starting volume for an on-site monitoring well. Depending on the response of the initial injection, a second injection can be made for confirmation. Up to 5.0 ml may be needed for concentrations in the low part-per-billion range. Highly concentrated samples may yield a response even before the plunger is depressed, since the vapor diffuses rapidly from the syringe.
- (7) The Strip Chart Recorder is started up, and the vapor is injected into the GC column injection port. In injecting this sample, it is not important to introduce the sample all at once, as in running a chromatogram. The sample should be introduced relatively slowly to avoid blowing out the flame in the FID. As the syringe plunger is depressed, the needle on the read-out meter and the pen (imprinter) on the Strip Chart Recorder will respond to the pressure produced by the injection. This response should not be misinterpreted as a response to the presence of volatiles, which may take place in 1 to 2 seconds.
- (8) If volatiles are present, a "backflush" peak will be recorded, and an upscale response of the needle on the read-out meter will be noted. If no volatiles are present, there will be no peak and no response.
- (9) The "backflush" peak height and duration of the upscale response related to the injection size are indicative of the total volatile organic compound concentration in the sample.
- (10) The sample number and injection size should be recorded directly on the strip chart paper. (See Section 8 and Figure 8-1.)

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- (11) After each sample, the gas-tight syringe should be flushed and a blank injection made to check cleanliness.

By using the technique described above, it is possible to quickly separate those samples not having volatiles and thus not requiring any further analysis from those containing volatiles. The latter samples will subsequently be run through GC screening.

6.2.2 GC Screening

The second phase of OVA sample screening involves running chromatograms on those samples which showed "backflush" peaks during the total volatile organic screening phase. The elements of the process are:

- (1) The BACKFLUSH VALVE is placed in the UP position so that the injected sample will run through the column.
- (2) A headspace vapor sample is withdrawn from the sample vial with a clean gas-tight syringe. The amount of vapor withdrawn is dependent on the best judgement of contaminant concentration from the response recorded during the total volatile screening of that sample. The size may be altered as subsequent injections are made.
- (3) The sample is introduced into the GC column with the Strip Chart Recorder running. The proper injection technique is important here, i.e., injecting the sample all at once. The injection event should also be marked on the strip chart.
- (4) Many water samples contain significant concentrations of methane, which elutes from the column in 1 to 2 seconds. (This screening phase may reveal that some samples showing "backflush" peaks during the total volatile screening contain only methane.) Because the methane may extinguish the FID flame in some instances, the operator should be prepared to relight the flame. It is not necessary to abort the chromatogram at this point, since the flame can usually be reignited within a few seconds.

- (5) Depending on the column being used and the column temperature, the chromatogram should be run for several minutes. The BACKFLUSH VALVE should then be depressed and the Strip Chart Recorder left running to record a total "backflush" peak which will occur if heavier compounds are still in the column. Keep in mind that activating the BACKFLUSH VALVE reverses the flow of carrier gas in the column, in this case sweeping the remaining compounds to the FID, where they are recorded as the "backflush" peak.
- (6) The column should be allowed to backflush for 1.5 times the length of the chromatogram.
- (7) If a chromatogram is to be run on a different sample, the syringe should be flushed with ambient air several times and checked for cleanliness by making a blank injection directly to the FID, before placing the BACKFLUSH VALVE in the UP position for the next chromatogram.
- (8) Chromatograms of blank injections should also be made at intervals during the analysis.
- (9) Experience has shown that a shorter column such as a T-6 is useful for initial chromatograms, especially under cool field conditions. At warmer temperatures, the Portable Isothermal Pack (PIP) assembly may be used. (See Glossary of Terms.)
- (10) If separation problems occur, longer columns or columns of different polarity may be employed.

6.2.3 Compound Identification

After chromatograms have been run on all samples showing the presence of volatiles, the samples containing only methane can be eliminated from further consideration. The next phase in sample analysis is compound identification, which requires the availability of a set of standards made up of volatile compounds likely to be water contaminants (see

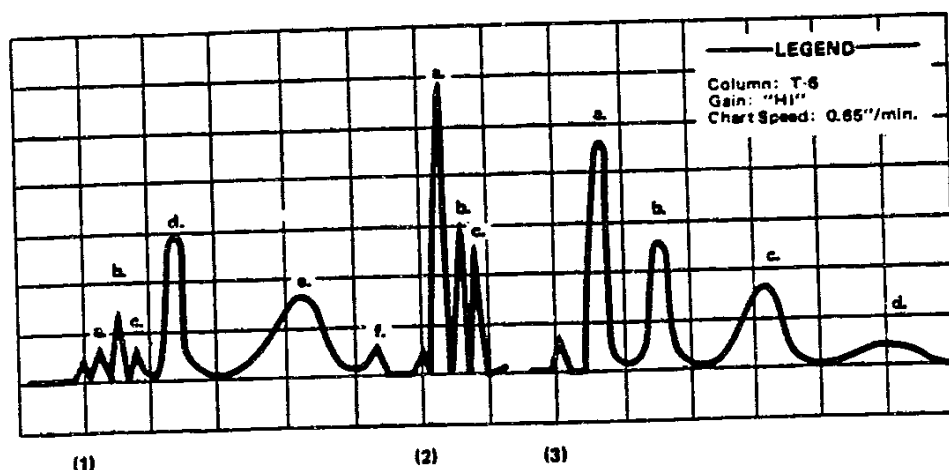
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Section 7 for information on standards). Since it is not feasible to have field standards available for all volatile organic compounds, it is important to check any available site background data which might identify compounds likely to be found.

The following approach is suggested for compound identification:

- (1) From a set of master analytical standards, a variety of mixtures of dilute aqueous solutions of volatile compounds can be prepared. For example, a solution containing benzene, toluene, xylene, and ethylbenzene could be prepared. Another solution containing trichloroethylene, 1,1,1-trichloroethane, and tetrachloroethylene could be prepared, and so on. The elution orders of the compounds in these mixtures will be constant for a given GC column and previously determined. (See Appendix F.) Chromatograms of these "knowns" are then made under the same conditions as the samples by making injections of headspace vapor.
- (2) The chromatograms of the "known" mixtures are compared to those of the samples to determine if there are apparent retention-time matches.
- (3) Apparent retention-time matches are noted and a different GC column fitted to the OVA. Chromatograms are run on the new column for the samples and the "knowns," and retention times are compared again.
- (4) A retention-time match on two different columns provides a fairly reliable identification; however, the requirements for absolute positive identification are more stringent (Section 4.3). FIT OVA operators are cautioned to include the word "tentative" or "preliminary" in all statements of identification. Figure 6-1 provides a schematic representation of qualitative technique.

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The above schematic representation is of chromatograms obtained by injecting headspace vapor from a water sample (1) and from dilute aqueous mixtures of known volatile organic compounds (2) and (3). Chromatograms of the samples and known standards were also run on different columns to confirm retention time matches.

- (1) 150 μ L Injection: (Small spike marks injection)
- a. 1,1,1-Trichloroethane
 - b. Trichloroethylene
 - c. Tetrachloroethane
 - d. Toluene
 - e. Ethylbenzene
 - f. Air Peak Due to Backflush Valve Activation
- (2) 100 μ L Injection: (Small spike marks injection)
- a. 1,1,1-Trichloroethane
 - b. Trichloroethylene
 - c. Tetrachloroethylene
- (3) 100 μ L Injection: (Small spike marks injection)
- a. Benzene
 - b. Toluene
 - c. Ethylbenzene
 - d. O-xylene

Figure 6-1 TYPICAL SAMPLE CHROMATOGRAM

6.2.4 Quantitation

Following tentative identification of compounds in the sample, a determination of concentration can be made if that information is desired. Quantitation requires that dilute aqueous solutions of the compounds to be quantified be prepared from the master standards. To make the process more expedient, peak height is used as the indicator of compound concentration. Preparation of the dilute solutions of known concentration is addressed in Section 7. An example of peak height analysis to determine compound concentration is given in Figure 6-2.

6.3 SOIL SAMPLES

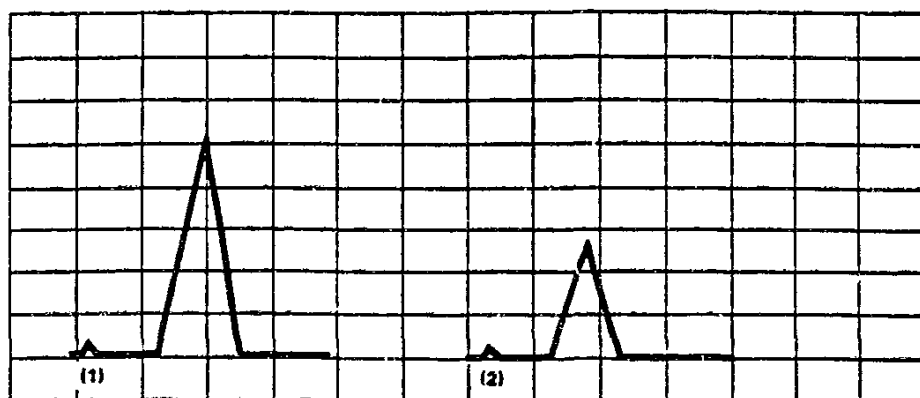
Soil samples for volatile organic analysis with the OVA can be processed by the same techniques described in Section 6.2. Precise quantitation of soil samples cannot be carried out in the same manner or as easily as water samples due to differences in soil densities, adsorption characteristics, moisture content, and other factors. Therefore, determination of concentrations of soil contaminants will at best be estimates based upon the OVA's response and the operator's experience.

6.3.1 Collection of Soil Samples

Soil samples are collected in volatile organics analysis (VOA) vials, leaving a headspace for vapor accumulation. Soil samples may be collected during installation of monitoring wells by taking small quantities from a split-spoon soil core. Samples may also be obtained by using a shovel or hand auger to penetrate the soil surface. Sample-collecting personnel should be instructed that only subsurface samples are to be taken since contaminants volatilize from the surface.

6.3.2 Preparation for Analysis

The samples should be allowed to thermally equilibrate to the temperature of the GC column prior to analysis. If the samples are cold, a warm water bath can be used to accelerate equilibration and the accumulation of vapor in the headspace. Avoid overheating because higher boiling components may condense on the GC column upon injection.



- (1) Schematic representation of a 100 μ L headspace vapor injection of a water sample. Compound has previously been identified as benzene. Peak height is 5 chart divisions.
- (2) Schematic representation of a 200 μ L headspace vapor injection of a 200 ppb standard prepared from a master standard. Peak height is 2.5 chart divisions.

The peak height in (1) is twice that of (2), and the injection size of (1) is one-half that of (2). Therefore, the concentration of the sample is four times that of the standard, or 800 ppb.

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Figure 6-2 PEAK-HEIGHT ANALYSIS

6.4 AIR SAMPLES

Air samples from "hot" areas of a site are again analyzed by following the procedures outlined in Section 6.2; however, a greater variety of techniques may be employed to collect air samples.

6.4.1 Air Sample Collection

The following techniques are suggested, and it is anticipated that additional techniques may be proposed from the field experiences of FET personnel.

- o Direct Introduction of Sample by OVA SAMPLE INJECT VALVE: The OVA and Strip Chart Recorder can be donned and taken into a site, where operation of the OVA in the survey mode can identify a "hot spot." A chromatogram can be run by activating the SAMPLE INJECT VALVE and switching the Strip Chart Recorder. Identification and quantitation can be accomplished off-site. A limitation of this technique is that the operator must remain standing still for several minutes while running the chromatogram.
- o Gas-Tight Syringe: An air sample can be obtained with a gas-tight syringe by returning to an on-site "hot spot" previously identified by an OVA or hNu survey. The syringe is flushed several times in the contaminated atmosphere, and a sample is drawn and carried off-site to an area where the OVA is set up for field analysis. The sample can then be injected into the GC column, a chromatogram run, and further qualitative/quantitative analysis performed.
- o Air Bag Sample: By connecting an intrinsically safe portable pump to a gas sampling bag, an air sample can be obtained from locations of interest on a site. The bag is then taken off-site to the field analytical area where a syringe can be used to withdraw samples of the air from the bag for injection into the GC column. An alternative injection method would be to attach the sample inlet probe of the OVA to the bag valve and perform an injection of the air from the bag by using the SAMPLE INJECT VALVE.

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- o Adsorption Tubes: By coupling an intrinsically safe portable pump to a sampling tube packed with charcoal, Tenax or some other adsorbent, air samples for volatile organic samples can be obtained for subsequent desorption (using a portable thermal desorber) and analysis with the OVA. Further guidance on this technique is forthcoming.

6.4.2 Air Sample Analysis

Qualitative analysis is accomplished by means of the technique described in Section 6.2.3, while quantitation is carried out using the peak-height technique. Preparation of quantitative standards is addressed in Section 7.

6.5 SAMPLE SCREENING WITH THE hNu

The hNu may be used to determine the presence or absence of volatiles in soil or groundwater samples by using the following technique:

- o Collect the soil or water sample in a glass container (VOA septum vial not needed) leaving a 25% headspace.
- o Shake water samples or allow soil samples to thermally equilibrate. (Samples may also be warmed in a water bath.)
- o Remove sample container cover and insert hNu probe extender into headspace. Record reading.

SECTION 7

PREPARATION OF STANDARDS

7.1 INTRODUCTION

The use of the OVA in the GC mode is not intended to replace laboratory GC/MS analysis. As a field analytical instrument, the OVA will provide rapid preliminary qualitative/quantitative data which can facilitate field operations and help laboratory personnel in their analysis.

The following sections on standard preparation are designed to be employed by field personnel using a minimum amount of equipment and time. Therefore, there is some latitude in the degree of precision involved in the preparation of quantitative field standards. It should be recognized that there will be absolute numerical discrepancies between field and laboratory-generated data; however, if a reasonable degree of attention is paid to the preparation of quantitative field standards, the relative discrepancies between field and laboratory data should be minimal. For example, the absolute difference between 4,000 ppb and 8,000 ppb is large, but the relative difference is hardly significant. Further, there is a marked advantage in knowing the concentration of a contaminant in a relative sense, as opposed to simply knowing that the contaminant is present.

7.2 MASTER STANDARD KITS

A set of standards which can easily be taken into the field is needed to perform qualitative and quantitative analyses with the OVA. Obviously, it is impossible to anticipate every type of volatile compound which might be encountered. Based on compounds commonly encountered by regional FIT personnel, an initial set of 23 "master standards" is being prepared for distribution to each regional OVA operator. Additional compounds may be acquired by the regions on a site-specific basis if background information indicates that compounds not included in the initial set are present in significant quantities at a site. Table 7-1 is a list of compounds to be included in the initial set. Also provided are the densities of each compound and solubility data. (Solubility data are not presently available for all compounds.)

TABLE 7-1
FIT MASTER STANDARDS

Compound	Density (g/ml)	Solubility in H ₂ O (ppm at 25°C)
1. Dichloromethane (methylene chloride) 85	1.326	13,000
2. Trichloromethane (chloroform) 107.5	1.483	8,850
3. Carbon tetrachloride	1.594	770
4. Dichloroethane (ethylene dichloride)	1.175	8,800
5. 1,2-trans dichloroethylene	1.235	
6. Trichloroethylene (TCE) 131.5	1.456	1,100
7. 1,1,1-trichloroethane 133.5	1.325	1,480
8. Tetrachloroethylene 166	1.593	*
9. Dimethyl ketone (acetone)	0.789	*
10. Methyl ethyl ketone (MEK)	0.815	247,000
11. Methyl isobutyl ketone (MIBK)	0.804	17,000
12. Benzene 78	0.879	1,780
13. Methyl benzene (toluene) 92	0.866	515
14. Chlorobenzene	1.105	463
15. Ethyl benzene 96	0.867	152
16. Nitro benzene	1.199	*
17. 1,2-dimethyl benzene (O-xylene) 108	0.868	175
18. 1,3-dimethyl benzene (m-xylene) 108	0.880	196
19. 1,4-dimethyl benzene (p-xylene) 108	0.861	198
20. Ethyl acetate	0.9003	*

*Solubility Data Not Currently Available

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TABLE A1 Solubility Characteristics of Organic Solvents

Solvent	Solubility * mg/litre (gms)	
	Solvent in Water	Water in Solvent
n-Pentane	34	120
Isopentane	48	106
Cyclohexane	65	100
Hexane	9.5	129
Heptane	2.9	91
n-Octane	0.64	111
Benzene	1 780	430
Toluene	311	334
o-Xylene	173	...
m-Xylene	196	480
p-Xylene	198	...
Ethyl benzene	132	430
Naphthalene	34.4	...
Styrene	310	680
Isobutanol	100 000	169 000
Cyclohexanol	37 500	122 000
n-Octanol	318	...
Phenol	86 600	28 700
o-Cresol	23 000	...
Ethyl ether	60 000	14 600
Isopropyl ether	13 000	6 300
Methyl ethyl ketone (MEK)	247 000	104 000
Methyl isobutyl ketone (MIBK)	17 000	19 000
Ethyl acetate	80 000	29 400
1,1,2-Trichloro-1,2,2-trifluoroethane	170	110
Chlorobenzene	463	327
Dichloromethane (methylene chloride)	13 000	1 940
Trichloromethane (chloroform)	8 430	760
Tetrachloromethane (carbon tetrachloride)	770	103
1,2-Dichloroethane	8 900	1 670
1,1,1-Trichloroethane	1 480	340
1,1,2,2-Tetrachloroethane	3 170	...
o-Dichlorobenzene	2,700	3 020
m-Dichlorobenzene	130	...
Trichloroethylene	1 100	3 200
Aniline	33 800	47 600
Carbon disulfide	3 210	260

* All values are based on Ref (6) corrected to 25°C.

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TABLE A1 Solubility Characteristics of Organic Solvents

Solvent	Solubility* mg/litre (ppm)	
	Solvent in Water	Water in Solvent
n-Pentane	34	120
Isopentane	48	106
Cyclohexane	65	140
Hexane	9.5	120
Heptane	2.9	91
n-Octane	0.66	111
Benzene	1 780	430
Toluene	515	334
o-Xylene	175	...
m-Xylene	196	460
p-Xylene	198	...
Ethyl benzene	152	430
Naphthalene	31.4	...
Styrene	310	660
Isobutanol	100 000	160 000
Cyclohexanol	37 500	122 000
n-Octanol	578	...
Phenol	86 600	28 700
o-Cresol	25 800	...
Ethyl ether	10 000	14 600
Isopropyl ether	13 000	6 200
Methyl ethyl ketone (MEK)	247 000	104 000
Methyl isobutyl ketone (MIBK)	17 000	19 000
Ethyl acetate	80 000	29 400
1,1,2-Trichloro-1,2,2-trifluoroethane	170	110
Chlorobenzene	463	327
Dichloromethane (methylene chloride)	13 000	1 940
Trichloromethane (chloroform)	8 850	760
Tetrachloromethane (carbon tetrachloride)	770	103
1,2-Dichloroethane	8 800	1 670
1,1,1-Trichloroethane	1 480	340
1,1,2,2-Tetrachloroethane	3 170	...
p-Dichlorobenzene	4,700	3 020
m-Dichlorobenzene	130	...
Trichloroethylene	1 100	3 200
Aniline	33 800	47 600
Carbon disulfide	5 240	600

* All values are based on Ref (6) corrected to 25°C.

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7.3 COMPOSITION OF MASTER STANDARDS

Each master standard consists of a saturated water solution of the particular compound. The standards are prepared by placing a small quantity (3 to 4 ml) of the pure solvent in a 40 or 44 ml VOA vial with distilled water. The total volume of solvent and water should be 75% of the vial volume, i.e., to leave a 25% headspace. An amount of mercury which is sufficient to cover the vial's septum when inverted is also placed in the vial. This prevents loss of the volatile solvent after the septum has been repeatedly pierced with a syringe.

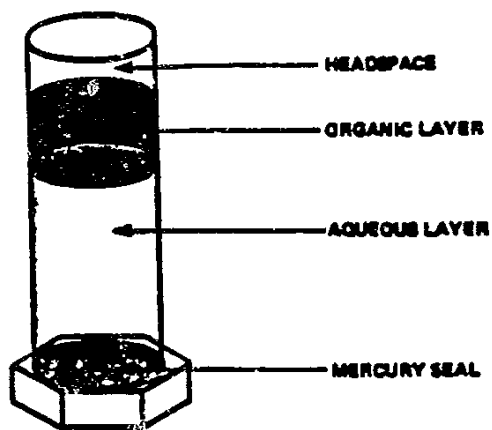
Since the majority of the compounds in Table 7-1 are relatively immiscible in water (notable exceptions are acetone, methanol, MEK, and MIBK), two layers will form in the vial, one organic and one aqueous. The densities of the individual compounds will determine whether the organic layer is above or below the water. Figure 7-1 is a schematic representation of master standard vials.

7.4 USE OF MASTER STANDARDS

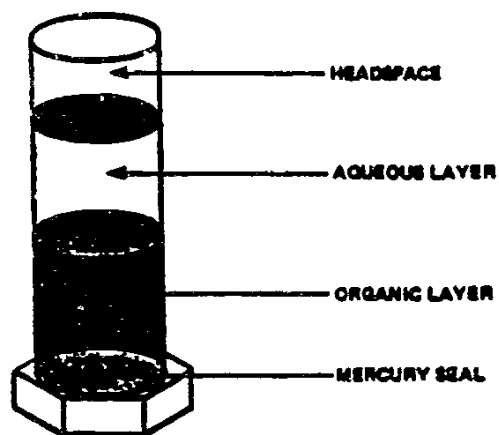
The master standards are intended to be used over the long term to prepare secondary standards for OVA analytical work. The secondary standards may be prepared for both qualitative and quantitative work. By using the mercury seal method, the secondary standards will also hold up over time. The following sections provide some specific guidance on the use of master standards.

7.4.1 Qualitative Standards

The basis of the approach to compound identification outlined in Section 6.2.3 was the use of a mixture of compounds to establish retention-time orders which could be employed to match the retention times of unknown compounds in a sample. The mixtures are prepared by removing 1 to 5 μ l of the saturated aqueous layer from each master standard desired and placing it in a VOA vial containing approximately 30 ml of distilled water. A syringe is used to obtain the aqueous portion from the master standard. Care should be taken to flush the syringe thoroughly with clean water after each master standard in order to prevent cross-contamination of standards. For example, a five-component qualitative standard can be prepared by combining small quantities of each of the



A. SOLVENT WITH LESS DENSITY THAN WATER



B. SOLVENT WITH GREATER DENSITY THAN WATER

Figure 7-1 MASTER STANDARDS

following from the individual master standards in one VOA vial: benzene, toluene, trichloroethylene, tetrachloroethylene, and ethylbenzene. For qualitative confirmation, individual secondary standards can also be prepared.

7.4.2 Preparation of Quantitative Standards (Solubility of Compound Known)

Table 7-1 lists available solubility data for several of the compounds in the master standards kits. Most of the literature sources that were checked list the compounds in Table 7-1 as simply "insoluble" or "slightly soluble." The solubility values given are at levels which are often considered to be significant for surface water and groundwater samples. Considering that laboratory GC/MS data available to FIT report compounds in low ppb concentrations, the fact that toluene is soluble in water to a level of 515 ppm is indeed significant. The CRC Handbook of Chemistry and Physics reports that toluene is insoluble.

Where specific solubility values are known, the preparation of quantitative standards from the master standards can be relatively fast and simple. Research performed by the Region I EPA laboratory has confirmed that the following approach can provide very reproducible quantitative standards. Further, the research has shown that variations in temperature, which can affect solubility values, are not significant enough to warrant correction. Figure 7-2 illustrates the use of the master standard and solubility data to prepare quantitative secondary standards. It is not the intent to provide a rigorous quantitative technique, but rather to provide field-expedient methods which go beyond simple qualitative work.

7.4.3 Preparation of Quantitative Standards (Solubility Unknown)

Where solubility data is presently unavailable for some of the standard compounds, quantitative standards can be prepared, although not as conveniently or as quickly as in the method described in Section 7.3.2. The quantitative standards can be prepared by making serial dilutions based on a 1:1 volume/volume relationship, or the density of the compound of interest can be incorporated into the calculation to yield more accurate standards. The pure solvent layer of the master standard is used. Figure 7-3 provides a schematic presentation of this technique.

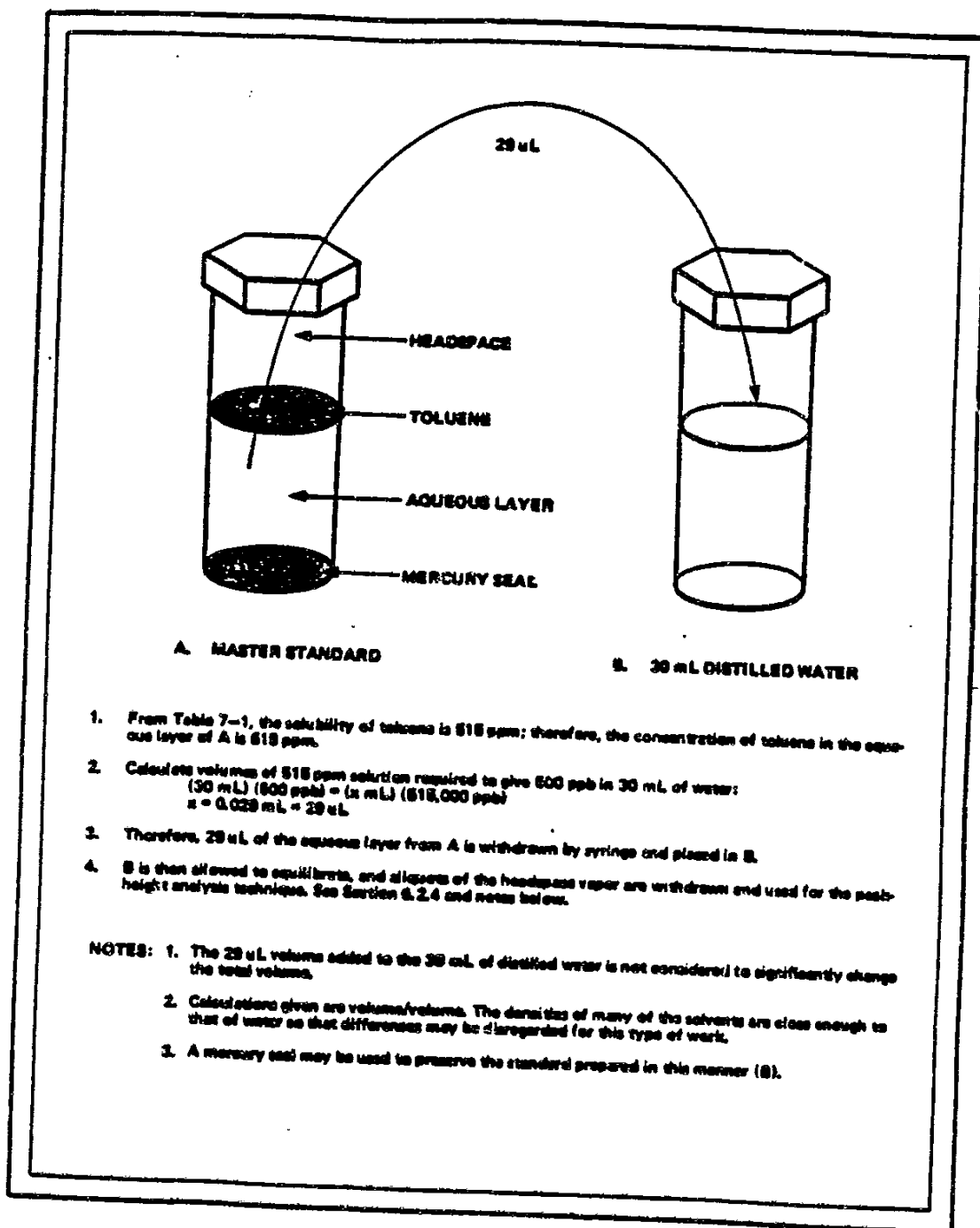


Figure 7-2 PREPARATION OF A 500 ppb STANDARD FOR TOLUENE

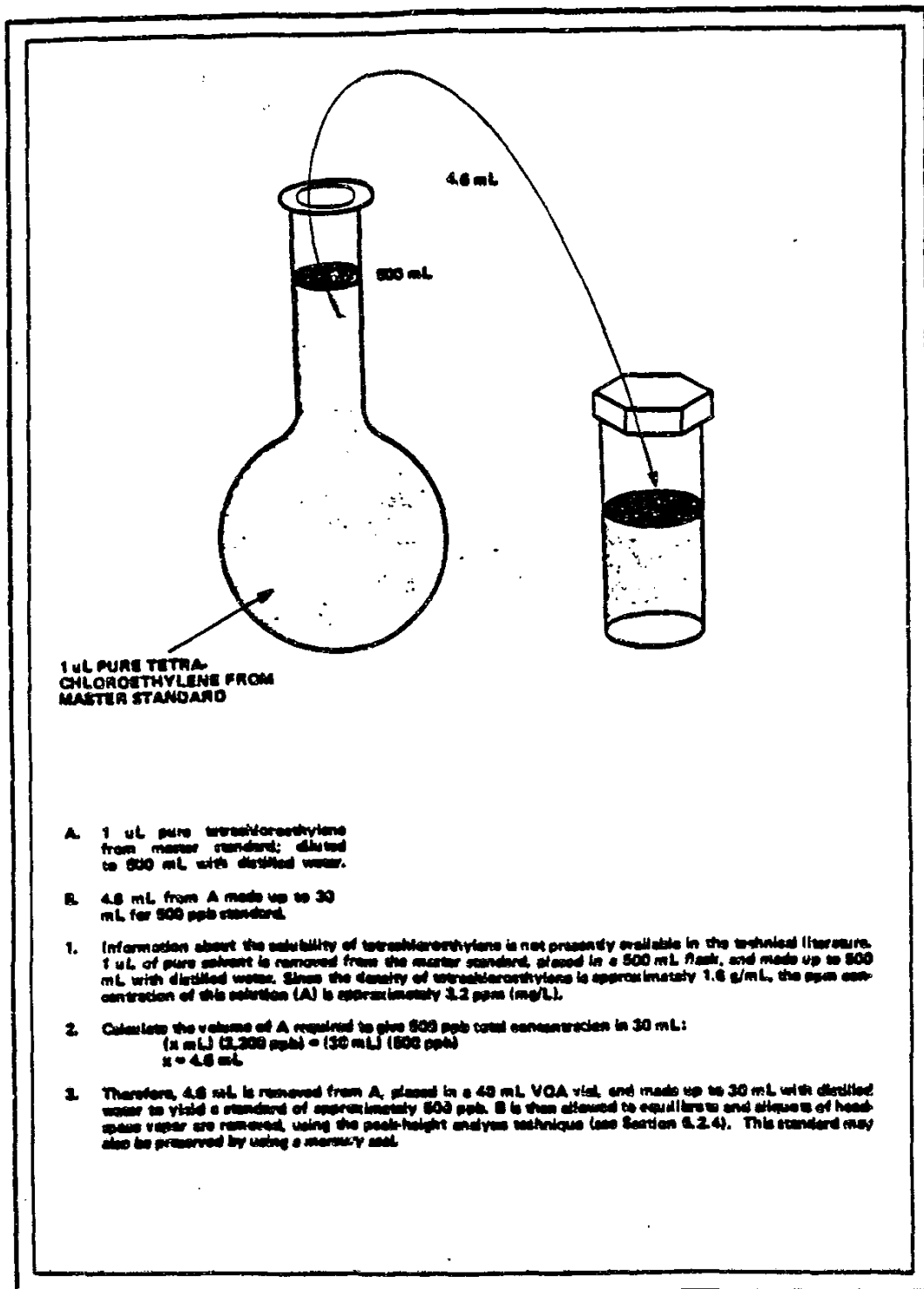


Figure 7-3 PREPARATION OF A 500 ppb STANDARD FOR TETRACHLOROETHYLENE

7.4.4 Preparation of Quantitative Standards for Air Sample Analysis

It is possible to quickly prepare a quantitative air standard by using quantities of pure solvent which are small enough to vaporize completely in a 40 ml VOA vial at ambient temperature. Figure 7-4 provides an illustration of this technique.

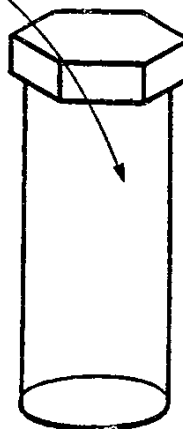
The following formula can be used for the preparation of vapor standards:

$$\begin{array}{lcl} \text{Concentration} & & \text{(density of solvent} \\ \text{of} & = & \text{in g/ml)} \\ \text{Vapor (ppm)} & = & \frac{(\text{ml of pure solvent})}{(\text{Volume of container} \\ & & \text{in liters)} \quad \frac{(24.45) \times 10^6}{(\text{Molecular weight of solvent} \\ & & \text{in grams)} \end{array}$$

NOTE: This assumes a temperature of 25°C and a pressure of 760 Torrs.

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1 μ L PURE SOLVENT
FROM MASTER STANDARD



1. 1 μ L of pure toluene is withdrawn from the master standard, injected into a clean, empty 40 mL VOA vial, and allowed to vaporize.
2. Using the formula presented in Section 7.3.4, the concentration of the standard is calculated as follows:

$$\frac{(0.001 \text{ mL}) (0.866 \text{ g/mL}) (24.45) \times 10^6}{(0.4 \text{ L}) (92 \text{ g})} = 5753 \text{ ppm} \approx 5800 \text{ ppm}$$
3. The standard thus prepared may be used to prepare standards of lesser concentration by further dilution on a volume/volume basis.

Figure 7-4 PREPARATION OF A TOLUENE VAPOR STANDARD

SECTION 8

REPORTING OF DATA

8.1 INTRODUCTION

The following sections address the recording, storage, and reporting of data generated by field analysis with the OVA. In addition, some simple "quality assurance" elements of OVA use on the FIT Project are presented.

8.2 RECORDING AND STORAGE OF DATA

The following information should be written directly on the strip chart as the actual qualitative/quantitative analysis takes place:

- o Date of Analysis: May be recorded once before running a group of chromatograms on the same date.
- o Type/Length of Column: For example, "G-24" would indicate a G-type, 24-inch column. This may also be recorded once before running a group of chromatograms, if the same column is used. Whenever the column is changed, it should be noted on the strip chart.
- o Chart Speed: For the Rus Trac recorder, indicate "slow" or "fast" gear train. Chart speed should be checked occasionally to determine the stability.
- o Sensitivity Range: X1, X10, or X100.
- o Recorder Gain: HIGH or LOW.
- o Injection Size: Volume of vapor injected for each chromatogram recorded.
- o Sample Numbers

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- o Activation of BACKFLUSH VALVE: Indication of where on chromatogram the BACKFLUSH VALVE was activated.
- o Purpose of Injection: Indicate whether the injection is a chromatogram or a total volatile organic determination.
- o Identification of Blank Injections
- o Ambient or Isothermal Temperature: Figure 8-1 provides an example of the above.

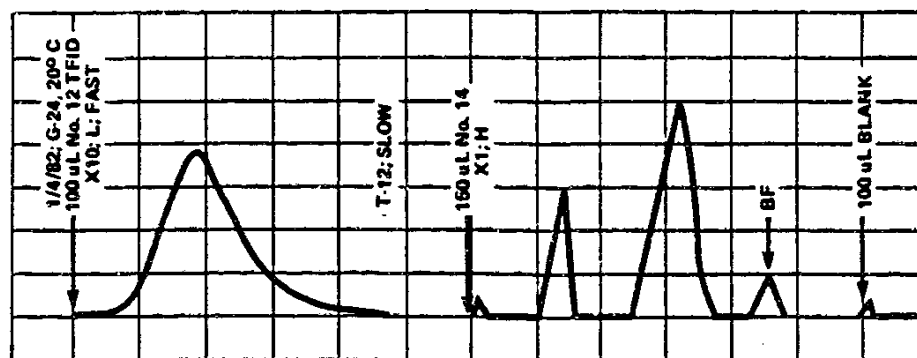
The chromatograms produced for samples obtained for a project will become a permanent part of the project records and file. Chromatograms can be affixed to the pages of a bound logbook, or they can be mounted on pages to be included in a three-ring binder. The binder or logbook should then be stored in the project file. In addition to the chromatograms for samples, the chromatograms of standards run during the sample analysis will be included. The chromatograms or data may not be admissible as court evidence, but the documentation provided by having the preliminary data readily accessible could be important to the ultimate outcome of a project.

Information about the conditions during analysis should be recorded under each affixed chromatogram to supplement the data recorded on the strip chart. Figure 8-2 provides an example of how to store chromatograms in a logbook and what data should be recorded.

8.3 REPORTING OF DATA

As each OVA operator gains experience, the data obtained will become more reliable; however, some analyses can elude the most seasoned operator and mistakes can be made in compound identification. The data generated by GC analysis in the field are not designed to take the place of laboratory GC/MS analysis, but rather to supplement laboratory analysis and to provide a means for field personnel to obtain data quickly in order to improve the technical approach of their work or increase their response capabilities in emergencies.

Therefore, when supplying OVA data for a report or memorandum, it is important that two adjectives accompany the results. All identification



- (1) 1/4/82 = Date of analysis
 G-24 = Column type/length
 200 C = Ambient temperature
 100 uL = Injection size
 No. 12 = Sample number
 TFID = "to flame ionization detector"; indicates injection with backflush valve in down position
 X10 = OVA sensitivity range
 L = Recorder gain setting
 FAST = Gear train used
- (2) T-12 = Column changed to this from type in (1)
 SLOW = Recorder gear train changed
 150 uL = Injection size
 No. 14 = Sample number
 X1 = OVA sensitivity range
 H = Recorder gain setting
 BF = Backflush valve activated
- (3) 100 uL blank = blank injection

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Figure 8-1 DATA TO BE RECORDED ON STRIP CHART

TOD.: _____

DATE: _____

AFFIX CHROMATOGRAM
NUMBER PEAKS IN SEQUENTIAL ORDER

COLUMN _____

TYPE OF INJECTION _____

STANDARD(S) _____

TEMPERATURE _____ COLUMN FLOW RATE _____

RANGE SETTING _____ RECORDER SETTING _____

INJECTION VOLUME _____ DILUTION FACTOR _____

QUALITATIVE/QUANTITATIVE ANALYSIS

<u>PEAK NO.</u>	<u>QUALITATIVE ID</u>	<u>QUANTITATIVE</u>	<u>GC/MS CONFIRMATION</u>	<u>COMMENT</u>
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COMMENTS:

OPERATOR:

Figure 8-2 STORAGE OF DATA

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of compounds should be reported as "tentative" and quantitations should be reported as "preliminary." This is especially important if the site is involved in litigation or there is a serious public health threat. The use of "tentative" or "preliminary" is not to be viewed as a means to hedge on OVA analyses. The inherent difficulties in GC field analyses make it necessary to clarify that the data obtained is indeed preliminary.

Further, if no compounds are detected with the OVA, it should be reported that no contaminants were found at "the limits of detection" of the instrument. The limits of detection vary with the response of the instrument to a given compound.

8.4 QUALITY ASSURANCE

A two-phased quality assurance (QA) program will be initiated in order to maintain documentation of the use of the OVA for field analyses in the FIT regions and to ensure that the data produced is as reliable as possible. The elements of this QA program are described as follows.

8.4.1 Chromatograms of Standards

Each certified OVA operator will submit to the FIT NPMO chromatograms of each of the volatile compounds included in the master standards kit. Information about the analysis should be written on the chromatogram, including column, chart speed, temperature, injection size, and standard compound identification.

8.4.2 Quality Assurance Samples

On a regular basis, the NPMO will send samples to the regional OVA operators for analysis. The results and chromatograms of the samples will be returned to the NPMO within the specified time. The purpose of this procedure is to ensure the quality of OVA data being generated within the regions and to identify any problems being encountered. Where problems are identified, assistance will be provided by the NPMO to the regions.

SECTION 9

RESOURCE LIST

Below are the names, addresses and telephone numbers of individuals who may be able to answer questions or provide help for problems encountered during the use of the OVA and hNu:

9.1 OVA

Paul Clay, AFITL, Region I
30 Cummings Park
Woburn, MA 01801 (617) 935-0228

John Panaro, Chemist, Region I
30 Cummings Park
Woburn, MA 01801 (617) 935-0228

Dr. Thomas Spittler, EPA Region I
60 Westview Street
Lexington, MA (617) 861-6700

Larry Robinson, OVA Repair/Maintenance
Foxboro-Wilkes
140 Water Street
S. Norwalk, CT 06856 (203) 853-1616

William Goode, Region V
223 West Jackson Boulevard
Chicago, IL 60606 (312) 663-9415

9.2 hNu

Paul Clay, AFITL, Region I
30 Cummings Park
Woburn, MA 01801 (617) 935-0228

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hNu Systems, Inc.
Service Dept.
(617) 964-6690, Ext. 42

William Goode, Region V
223 West Jackson Boulevard
Chicago, IL 60606 (312) 663-9415

Geoff Hewitt, General Sales Mgr.
hNu Systems, Inc.
30 Ossipee Road
Newton, MA 01264 (617) 964-6690

9.3 PROJECT COORDINATION

Robert King, FIT/ANPM
1700 N. Moore Street
Rosslyn Center
Arlington, VA (703) 522-6065

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APPENDIX A: OVA TROUBLESHOOTING GUIDE

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TROUBLE SHOOTING - SURVEY MODE OPERATION

TROUBLE	TROUBLE SHOOTING PROCEDURE	REMEDY
1) Low sample flow rate on flow indicator. Nominally 2 units on flow gauge. (See also 6 below)	<p>a) Check primary filter in sidepack and particle filters in the pickup assembly.</p> <p>b) Determine assembly containing restriction by process of elimination, i.e., remove probe, remove Readout Assembly, remove primary filter, etc.</p> <p>c) If the restriction is in the Side Pack Assembly, further isolate by disconnecting the sample flow tubing at various points, i.e., pump output, chamber input, etc. <u>Note:</u> The inherent restrictions due to length of sample line, flame arrestors, etc., must be taken into account when trouble shooting.</p>	<p>Replace or clean filter if clogged.</p> <p>Investigate the assembly containing this restriction to determine cause of blockage. Clean or replace as required.</p> <p>If in the detector chamber, remove and clean or replace porous metal flame arrestors. If pump is found to be the problem, remove and clean or replace.</p>
2) H2 flame will not light. (See also 6 below)	<p>a) Check sample flow rate (see 1 above)</p> <p>b) Check igniter by removing the chamber exhaust port and observing the glow when the IGNITE Button is depressed.</p> <p>c) Check for rated H2 Supply Pressure. (Listed on calibration plate on pump bracket.)</p> <p>d) Check H2 flow rate by observing the PSI decrease in pressure on the H2 tank Pressure gauge. The flow rate should be about 130 PSI decrease in pressure per hour. (Approximately 12 cc/min. at detector.) On instruments with GC Option, disconnect column and measure H2 flow rate with a bubble meter.</p> <p>e) Check all H2 plumbing joints for leaks using soap bubble solution. Also, shut off all valves and note pressure decay on H2 tank gauge. It should be less than 350 PSIG per hour.</p>	<p>If sample flow rate is low, follow procedure 1 above.</p> <p>If igniter does not light up, replace the plug. If igniter still does not light, check the battery and wiring.</p> <p>If low, remove battery pack and adjust to proper level by turning the allen wrench adjustment on the low pressure regulator cap.</p> <p>The normal cause for H2 flow restriction would be a blocked or partially blocked capillary tube. If flow rate is marginally low, attempt to compensate by increasing the H2 Supply Pressure by one-half or one PSI. If flow rate cannot be compensated for, replace capillary tubing.</p> <p>Repair leaking joint.</p>

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TROUBLE SHOOTING - SURVEY MODE OPERATION

TROUBLE	TROUBLE SHOOTING PROCEDURE	REMEDY
2) Continued from Page A-1	<p>f) Check to see if H2 supply system is frozen up by taking unit into a warm area.</p> <p>g) Remove exhaust port and check for contamination.</p> <p>h) Check spacing between collecting electrode and burner tip. Spacing should be 0.1 to 0.15 inches.</p>	<p>If there is moisture in the H2 supply system and the unit must be operated in subfreezing temperatures, purge the H2 system with dry N2 and ensure the H2 gas used is dry.</p> <p>If the chamber is dirty, clean with ethyl alcohol and dry by running pump for approximately 15 minutes. If H2 fuel jet is misaligned, ensure the porous metal flame arrestor is properly seated.</p> <p>Adjust by screwing Mixer/Burner Assembly in or out. This spacing problem should only occur after reassembling a Mixer/Burner Assembly to a Preamp Assembly.</p>
3) H2 flame lights but will not stay lighted	a) Follow procedures 2 (a), (c), (d), (e), (g), and (h) above. Also refer to 5 below.	
4) Flame-out alarm will not go on when H2 flame is out	<p>a) Check instrument calibration setting and GAS SELECT control setting.</p> <p>b) Remove exhaust port and check for leakage current path in chamber (probably moisture or dirt in chamber).</p> <p>c) If above procedures do not resolve the problem, the probable cause is a malfunction in the preamp or power board assemblies.</p> <p>d) Check volume control knob is turned up.</p>	<p>Readjust as required to proper setting. Note that on linear OVA's the flame-out alarm is actuated when the meter reading goes below zero.</p> <p>Clean contamination and/or moisture from the chamber using a swab and alcohol, dry chamber by running pump for approximately 15 minutes.</p> <p>Return preamp chamber or power board assembly to the factory for repair.</p> <p>Adjust for desired volume.</p>

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TRUBLE SHOOTING - SURVEY MODE OPERATION

TRUBLE	TRUBLE SHOOTING PROCEDURE	REMEDY
5) False Flame-out Alarm.	a) Flame-out alarm is actuated on linear instruments when signal goes below electronic zero (even though flame is still on). This can be due to inaccurate initial setting, drift or a decrease in ambient concentration. Verify if this is the problem by zeroing meter with flame out and reigniting.	When using the X1 range, adjust meter to 1 ppm rather than zero. Be sure instrument has been zeroed to "lowest expected ambient background level."
6) Slow response time, i.e., time to obtain response after sample is applied to input.	a) Check to ensure that probe is firmly seated on the rubber seal in the readout assembly. b) Check sample flow rate per procedure 1 above.	Reseat by holding the probe firmly against the rubber seat and then lock in position with the knurled locking nut. See 1 above.
7) Slow recovery time, i.e., too long a time for the reading to get back to ambient after exposure to a high concentration of organic vapor.	a) This problem is normally caused by contamination in the sample input line, requiring pumping for a long period to get the system clean of vapors again. Charcoal in the lines would be the worst type of contamination. Isolate through the process of elimination. (See 1(b)). b) Check flame chamber for contamination.	Clean or replace contaminated sample line or assembly as required. Clean as required.
8) Ambient background reading in clean environment is too high.	a) An ambient background reading can be caused by hydrocarbons in the H2 fuel supply system. Place finger over sample probe tube restricting sample flow and if meter indication does not go down significantly the contamination is probably in the H2 fuel. b) An ambient background reading can be caused by a residue of sample, building up on the face of the sample inlet filter. If the test in 8(a) above produces a large drop in reading, this is usually the cause.	Use a higher grade of hydrocarbon free hydrogen. Check for contaminated fittings on filling hose assembly. Remove the exhaust port (it is not necessary to remove instrument from case), use small wire brush from the tool kit or a knife blade and lightly scrub surface of sample inlet filter.

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TROUBLE SHOOTING - SURVEY MODE OPERATION

TROUBLE	TROUBLE SHOOTING PROCEDURE	REMEDY
8) Continued from Page A-3	c) An ambient background reading can also be caused by hydrogen contamination in the sample input system. The most likely cause would be a contaminant absorbed or condensed in the sample line. <u>Note:</u> It should be emphasized that running the instrument tends to keep down the buildup of background vapors. Therefore, run the unit whenever possible and store it with the carrying case open in clean air.	Clean and/or replace the sample input lines. Normally the lines will clear up with sufficient running.
9) Pump will not run	None Possible	Return OVA to authorized repair facility.
10) No power to electronics but pump runs	None Possible	Return OVA to authorized repair facility.
11) No power to pump or electronics.	a) Place battery on charger and see if power is then available. Recharge in a non-hazardous area.	If power is available, battery pack is dead or open. Recharge battery pack. If still defective, replace battery pack.

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TROUBLE SHOOTING: GC MODE OPERATION

TROUBLE	TROUBLE SHOOTING PROCEDURE	REMEDY
1) Low sample flow rate on flow indicator	a) Check teflon tubing on valve assembly for kinks, etc. b) Check flow rate with valve in down position.	Straighten or replace teflon tubing Check for over restriction of charcoal filter
2) H ₂ flame will not light	a) Check column connections on top of unit to make sure they are tight. b) Check column for sharp bends or kinks. (Hydrogen flows through this column at all times and a sharp bend will compact packing too tightly for proper hydrogen flow.) c) Check charcoal filter fittings to make sure they are tight. d) Check H ₂ flow rate from the column. e) Check that the inject and Backflush Valves are both completely in or out. A partially activated valve will block the H ₂ and air flow paths. f) If a new column was installed prior to problem identification, check for proper hydrogen flow rate through the column (should be approximately 12 cc/minute).	Tighten fittings Replace column Tighten fittings Adjust hydrogen pressure to obtain 12 cc/min. Ensure both valves are either completely in or out. Increase hydrogen pressure to obtain proper hydrogen flow rate or if column is excessively restrictive, replace or repack the column.
3) Ambient background reading in clean environment is too high	a) Check for contamination in charcoal filter assembly. This can be detected if ambient reading increases when going in to the chromatographic mode. b) Check for contamination in column.	Replace activated charcoal in charcoal filter assembly. Replace or clean column.

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TROUBLE SHOOTING: GC MODE OPERATION

TROUBLE	TROUBLE SHOOTING PROCEDURE	REMEDY
3) Continued from Page A-5	c) Check for contamination in column valve assembly.	Remove valve stems and wipe with clean lint-free cloth. Heat valve assembly during operation to vaporize and remove contaminants.
4) Flame-out when operating either valve	<p>a) Ensure valves are being operated with a quick, positive motion.</p> <p>b) Either H₂ or air may be leaking around one or more of the valve quad rings. Assess by tests and "O" ring inspection.</p> <p>c) Damaged or worn quad rings causing leak.</p>	<p>Operate valve with a positive motion.</p> <p>Remove stems and lightly coat with silicone grease, only on contact surface of the "O" ring. Wipe off excess (do not remove quad rings).</p> <p>Replace quad rings and grease as above.</p>
5) Excessive peak tailing	<p>a) Change or clean GC column and see if problem disappears.</p> <p>b) Inspect GC valves for excessive silicone grease or contamination.</p>	<p>Ensure columns are clean prior to use. If one of a same type of column tails worse than others, repack the column or discard.</p> <p>Excessive lubricant or foreign matter in the valve assembly can cause excessive tailing. Clean valve assembly and lightly relubricate as required. Lubricant should be put only on the outside contact surface of the "O" ring. Do not get grease into "O" ring grooves.</p>

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001667

APPENDIX B: COPY OF EXEMPTION LETTER
FOR CARRYING HYDROGEN-FILLED OVA ON
PASSENGER AIRCRAFT

001668



DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS
WASHINGTON, DC 20590
DOT-E 7607

(FIRST REVISION - CORRECTED COPY)

DRAFT

1. Century Systems Corporation, Arkansas City, Kansas, is hereby granted an exemption from those provisions of this Department's Hazardous Materials Regulations specified in paragraph 5 below to offer packages prescribed herein of a flammable gas for transportation in commerce subject to the limitations and special requirements specified herein. This exemption authorizes the shipment of hydrogen in certain non-DOT specification cylinders as described in paragraph 7 below, and provides no relief from any regulation other than as specifically stated. Each of the following is hereby granted the status of a party to this exemption:

U.S. Department of Health, Education and Welfare, Rockville,
Maryland - PTE-1.

2. BASIS. This exemption is based on Century Systems Corporation's application dated March 10, 1978, submitted in accordance with 49 CFR 107.105 and the public proceeding thereon. The granting of party status is based on the following application submitted in accordance with 49 CFR 107.111 and the public proceeding thereon:

The U.S. Department of Health, Education and Welfare's application dated March 13, 1978.

3. HAZARDOUS MATERIALS (Descriptor and class). Hydrogen, flammable gas.
4. PROPER SHIPPING NAME (49 CFR 172.101). Hydrogen.
5. REGULATION AFFECTED. 49 CFR 172.101, 175.3.
6. MODE OF TRANSPORTATION AUTHORIZED. Passenger-carrying aircraft.
7. SAFETY CONTROL MEASURES. Packaging prescribed is a non-DOT specification seamless stainless steel cylinder of not more than 7.22 cubic inch water capacity; each cylinder to be pressure tested to at least 4000 psig, and charged to not more than 2100 psig at 70°F. The cylinder is a component part of a portable gas chromatograph.
8. SPECIAL PROVISIONS.
 - a. Each device must be shipped in a strong outside packaging as prescribed in 49 CFR 173.301(k).
 - b. A copy of this exemption must be carried aboard each aircraft used to transport packages covered by this exemption.
 - c. The pilot in command must be advised when the gas chromatograph is placed on board the aircraft.
 - d. The gas chromatograph must be appropriately secured.

SEP 18 1980


Continuation of 1st Rev. DOT-E 7607 corrected copy

DRAFT

9. REPORTING REQUIREMENTS. Any incident involving loss of contents of the package must be reported to the Office of Hazardous Materials Regulation as soon as practicable.

10. EXPIRATION DATE. May 1, 1980.

Issued at Washington, D.C.:


Alan I. Roberts
Associate Director for
Hazardous Materials Regulation
Materials Transportation Bureau

9-7-78
(DATE)

Address all inquiries to: Associate Director for Hazardous Materials Regulation, Materials Transportation Bureau, Research and Special Programs Administration, Department of Transportation, Washington, D.C., 20590. Attention: Exemptions Branch.

Dist: B of E, FAA

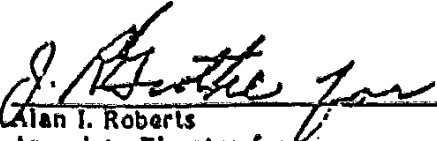


DEPARTMENT OF TRANSPORTATION
RESEARCH AND SPECIAL PROGRAMS ADMINISTRATION
WASHINGTON, D.C. 20590

DOT-E 7607
(PTE)

In accordance with 49 CFR 107.111 of the Department of Transportation (DOT) Hazardous Materials Regulations the party(s) listed below are granted the status of party to DOT-E 7607.

The expiration date of the exemption is March 11, 1982 for the party(s) listed below. This authorization forms part of the exemption and must be attached to it.


Alan I. Roberts
Associate Director for
Hazardous Materials Regulation
Materials Transportation Bureau

13 JUN 1980
(DATE)

Dist: FAA

EXEMPTION HOLDER

Clayton Environmental Consultants, Inc.
Southfield, Michigan

Foxboro Company
Burlington, MA

APPLICATION DATE

December 5, 1979

March 24, 1980

001670




US Department
of Transportation
Research and
Special Programs
Administration

400 Seventh Street, S.W.
Washington, D.C. 20590

DOT-E 7607
(EXTENSION)

In accordance with 49 CFR 107.105 of the Department of Transportation (DOT) Hazardous Materials Regulations DOT-E 7607 is hereby extended by changing the expiration date in paragraph 10 from December 1, 1983 to September 1, 1985.

This extension applies only to party(s) listed below based on the application received in accordance with 49 CFR 107.105. All other terms of the exemption remain unchanged. This extension forms part of the exemption and must be attached to it.


Alan I. Roberts
Associate Director for
Hazardous Materials Regulation
Materials Transportation Bureau

Dist: FAA

OCT 27 1983
(DATE)

EXEMPTION HOLDER

Foxboro Company
South Norwalk, Ct.

APPLICATION DATE

September 16, 1983

001671

APPENDIX C: IONIZATION POTENTIALS OF
SELECTED MOLECULES

001672

TABLE C-1
IONIZATION POTENTIALS (IP) OF
SOME ATOMS AND SIMPLE MOLECULES

	<u>IP (eV)</u>		<u>IP (eV)</u>
H	13.595	I ₂	9.28
C	11.264	HF	15.77
N	14.54	HCl	12.74
O	13.614	HBr	11.62
Si	8.149	HI	10.38
S	10.357	SO ₂	12.34
F	17.42	CO ₂	13.79
Cl	13.01	COS	11.18
Br	11.84	CS ₂	10.08
I	10.48	N ₂ O	12.90
H ₂	15.426	NO ₂	9.78
N ₂	15.580	O ₃	12.80
O ₂	12.075	H ₂ O	12.59
CO	14.01	H ₂ S	10.46
CN	15.13	H ₂ Se	9.88
NO	9.25	H ₂ Te	9.14
CH	11.1	HCN	13.91
OH	13.18	C ₂ N ₂	13.8
F ₂	15.7	NH ₃	10.15
Cl ₂	11.48	CH ₃	9.840
Br ₂	10.55	CH ₄	12.98

001673

TABLE C-2

IONIZATION POTENTIALS (IP) OF
SOME PARAFFINS AND CYCLOPARAFFINS

<u>Molecule</u>	<u>IP (eV)</u>
methane	12.98
ethane	11.65
propane	11.07
n-butane	10.63
i-butane	10.57
n-pentane	10.35
i-pentane	10.32
2,2-dimethylpropane	10.35
n-hexane	10.18
2-methylpentane	10.12
3-methylpentane	10.08
2,2-dimethylbutane	10.06
2,3-dimethylbutane	10.02
n-heptane	10.08
2,2,4-trimethylpentane	9.86
cyclopropane	10.06
cyclopentane	10.53
cyclohexane	9.88
methylcyclohexane	9.85

001674

TABLE C-3

IONIZATION POTENTIALS (IP) OF
SOME ALKYL HALIDES

<u>Molecule</u>	<u>IP (eV)</u>
HCl	12.74
Cl ₂	11.48
CH ₄	12.98
methyl chloride	11.28
dichloromethane	11.35
trichloromethane	11.42
tetrachloromethane	11.47
ethyl chloride	10.98
1,2-dichloroethane	11.12
1-chloropropane	10.82
2-chloropropane	10.78
1,2-dichloropropane	10.87
1,3-dichloropropane	10.85
1-chlorobutane	10.67
2-chlorobutane	10.65
1-chloro-2-methylpropane	10.66
2-chloro-2-methylpropane	10.61
HBr	11.62
Br ₂	10.55
methyl bromide	10.53
dibromomethane	10.49
tribromomethane	10.51
CH ₂ BrCl	10.77
CHBr ₂ Cl	10.59
ethyl bromide	10.29
1,1-dibromoethane	10.19
1-bromo-2-chloroethane	10.63

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TABLE C-3 (Cont.)
IONIZATION POTENTIALS (IP) OF
SOME ALKYL HALIDES

<u>Molecule</u>	<u>IP (eV)</u>
CF ₂ Br ₂	11.07
CH ₃ CF ₂ Cl (Genetron 101)	11.98
CFC1 ₂ CF ₂ Cl	11.99
CF ₃ CCl ₃ (Freon 113)	11.78
CFHBrCH ₂ Br	10.75
CF ₂ BrCH ₂ Br	10.83
CF ₃ CH ₂ I	10.00
n-C ₃ F ₇ I	10.36
n-C ₃ F ₇ CH ₂ Cl	11.84
n-C ₃ F ₇ CH ₂ I	9.96
1-bromopropane	10.18
2-bromopropane	10.075
1,3-dibromopropane	10.07
1-bromobutane	10.13
2-bromobutane	9.93
1-bromo-2-methylpropane	10.09
2-bromo-2-methylpropane	9.89
1-bromopentane	10.10
HI	10.38
I ₂	9.28
methyl iodide	9.54
diiodomethane	9.34
ethyl iodide	9.33
1-iodopropane	9.26
2-iodopropane	9.17

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TABLE C-3 (Cont.)
IONIZATION POTENTIALS (IP) OF
SOME ALKYL HALIDES

<u>Molecule</u>	<u>IP (eV)</u>
1-iodobutane	9.21
2-iodobutane	9.09
1-iodo-2-methylpropane	9.18
2-iodo-2-methylpropane	9.02
1-iodopentane	9.19
F ₂	15.7
HF	15.77
CFC1 ₃ (Freon 11)	11.77
CF ₂ Cl ₂ (Freon 12)	12.31
CF ₃ Cl (Freon 13)	12.91
CHClF ₂ (Freon 22)	12.45

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TABLE C-4
IONIZATION POTENTIALS (IP) OF
ALIPHATIC ALCOHOL, ETHER, THIOL, AND SULFIDES

<u>Molecule</u>	<u>IP (eV)</u>
H ₂ O	12.59
methyl alcohol	10.85
ethyl alcohol	10.48
n-propyl alcohol	10.20
i-propyl alcohol	10.16
n-butyl alcohol	10.04
dimethyl ether	10.00
diethyl ether	9.53
n-propyl ether	9.27
i-propyl ether	9.20
H ₂ S	10.46
methanethiol	9.440
ethanethiol	9.285
1-propanethiol	9.195
1-butanethiol	9.14
dimethyl sulfide	8.685
ethyl methyl sulfide	8.55
diethyl sulfide	8.430
di-n-propyl sulfide	8.30

001678

TABLE C-5

IONIZATION POTENTIALS (IP) OF
SOME ALIPHATIC ALDEHYDES AND KETONES

<u>Molecule</u>	<u>IP (eV)</u>
CO ₂	13.79
formaldehyde	10.87
acetaldehyde	10.21
propionaldehyde	9.98
n-butyraldehyde	9.86
isobutyraldehyde	9.74
n-valeraldehyde	9.82
isovaleraldehyde	9.71
acrolein	10.10
crotonaldehyde	9.73
benzaldehyde	9.53
acetone	9.69
methyl ethyl ketone	9.53
methyl n-propyl ketone	9.39
methyl i-propyl ketone	9.32
diethyl ketone	9.32
methyl n-butyl ketone	9.34
methyl i-butyl ketone	9.30
3,3-dimethyl butanone	9.17
2-heptanone	9.33
cyclopentanone	9.26
cyclohexanone	9.14
2,3-butanedione	9.23
2,4-pentanedione	8.87

001679

TABLE C-6

IONIZATION POTENTIALS (IP) OF
SOME ALIPHATIC ACIDS AND ESTERS

<u>Molecule</u>	<u>IP (eV)</u>
CO ₂	13.79
formic acid	11.05
acetic acid	10.37
propionic acid	10.24
n-butyric acid	10.16
isobutyric acid	10.02
n-valeric acid	10.12
methyl formate	10.815
ethyl formate	10.61
n-propyl formate	10.54
n-butyl formate	10.50
isobutyl formate	10.46
methyl acetate	10.27
ethyl acetate.	10.11
n-propyl acetate	10.04
isopropyl acetate	9.99
n-butyl acetate	10.01
isobutyl acetate	9.97
sec-butyl acetate	9.91
methyl propionate	10.15
ethyl propionate	10.00
methyl n-butyrate	10.07
methyl isobutyrate	9.98

001680

TABLE C-7
IONIZATION POTENTIALS (IP) OF
SOME ALIPHATIC AMINES AND AMIDES

<u>Molecule</u>	<u>IP (eV)</u>
NH ₃	10.15
methyl amine	8.97
ethyl amine	8.86
n-propyl amine	8.78
i-propyl amine	8.72
n-butyl amine	8.71
i-butyl amine	8.70
s-butyl amine	8.70
t-butyl amine	8.64
dimethyl amine	8.24
diethyl amine	8.01
di-n-propyl amine	7.84
di-i-propyl amine	7.73
di-n-butyl amine	7.69
trimethyl amine	7.82
triethyl amine	7.50
tri-n-propyl amine	7.23
formamide	10.25
acetamide	9.77
N-methyl acetamide	8.90
N,N-dimethyl formamide	9.12
N,N-dimethyl acetamide	8.81
N,N-diethyl formamide	8.89
N,N-diethyl acetamide	8.60

001681

TABLE C-8

IONIZATION POTENTIALS (IP) OF
OTHER ALIPHATIC MOLECULES WITH N ATOM

<u>Molecule</u>	<u>IP (eV)</u>
nitromethane	11.08
nitroethane	10.88
1-nitropropane	10.81
2-nitropropane	10.71
HCN	13.91
acetonitrile	12.22
propionitrile	11.84
n-butyronitrile	11.67
acrylonitrile	10.91
3-butene-nitrile	10.39
ethyl nitrate	11.22
n-propyl nitrate	
methyl thiocyanate	10.065
ethyl thiocyanate	9.89
methyl isothiocyanate	9.25
ethyl isothiocyanate	9.14

001682

TABLE C-9

IONIZATION POTENTIALS (IP) OF
SOME OLEFINS, CYCLO-OLEFINS, POLENES, ACETYLENES

<u>Molecule</u>	<u>IP (eV)</u>
ethylene	10.515
propylene	9.73
1-butene	9.58
2-methylpropene	9.23
trans-2-butene	9.13
cis-2-butene	9.13
1-pentene	9.50
2-methyl-1-butene	9.12
3-methyl-1-butene	9.51
3-methyl-2-butene	8.67
1-hexene	9.46
1,3-butadiene	9.07
isoprene	8.845
cyclopentene	9.01
cyclohexene	8.945
4-methylcyclohexene	8.91
4-cinylcyclohexene	8.93
cyclo-octatetraene	7.99
acetylene	11.41
propyne	10.36
1-butyne	10.18

001683

TABLE C-10

IONIZATION POTENTIALS (IP) OF
SOME DERIVATIVES OF OLEFINS

<u>Molecule</u>	<u>IP (eV)</u>
vinyl chloride	9.995
cis-dichloroethylene	9.65
trans-dichloroethylene	9.66
trichloroethylene	9.45
tetrachloroethylene	9.32
vinyl bromide	9.80
1,2-dibromoethylene	9.45
tribromoethylene	9.27
3-chloropropene	10.04
2,3-dichloropropene	9.82
1-bromopropene	9.30
3-bromopropene	9.7
$\text{CF}_3\text{CCl}=\text{CClCF}_3$	10.36
$n\text{-C}_5\text{F}_{11}\text{CF}=\text{CF}_2$	10.48
acrolein	10.10
crotonaldehyde	9.73
mesityl oxide	9.08
vinyl methyl ether	8.93
allyl alcohol	9.67
vinyl acetate	9.19

001684

TABLE C-11
IONIZATION POTENTIALS (IP) OF
SOME HETEROCYCLIC MOLECULES

<u>Molecule</u>	<u>IP (eV)</u>
furan	8.89
2-methyl furan	8.39
2-furaldehyde	9.21
tetrahydrofuran	9.54
dihdropyran	8.34
tetrahydropyran	9.26
thiophene	8.860
2-chlorothiophene	8.68
2-bromothiophene	8.63
pyrrole	8.20
pyridine	9.32
2-picoline	9.02
3-picoline	9.04
4-picoline	9.04
2,3-lutidine	8.85
2,4-lutidine	8.85
2,6-lutidine	8.85

001685

TABLE C-12
IONIZATION POTENTIALS (IP) OF
SOME AROMATIC COMPOUNDS

<u>Molecule</u>	<u>IP (eV)</u>
benzene	9.245
toluene	8.82
ethyl benzene	8.76
n-propyl benzene	8.72
i-propyl benzene	8.69
n-butyl benzene	8.69
s-butyl benzene	8.68
t-butyl benzene	8.68
o-xylene	8.56
m-xylene	8.56
p-xylene	8.445
mesitylene	8.40
durene	8.025
styrene	8.47
α -methyl styrene	8.35
ethynylbenzene	8.815
naphthalene	8.12
1-methylnaphthalene	7.96
2-methylnaphthalene	7.955
biphenyl	8.27
phenol	8.50
anisole	8.22
phenetole	8.13

001686

TABLE C-12 (Cont.)

IONIZATION POTENTIALS (IP) OF
SOME AROMATIC COMPOUNDS

<u>Molecule</u>	<u>IP (eV)</u>
benzaldehyde	9.53
acetophenone	9.27
benzenethiol	8.33
phenyl isocyanate	8.77
phenyl isothiocyanate	8.520
benzonitrile	9.705
nitrobenzene	9.92
aniline	7.70
fluoro-benzene	9.195
chloro-benzene	9.07
bromo-benzene	8.98
iodo-benzene	8.73
o-dichlorobenzene	9.07
m-dichlorobenzene	9.12
p-dichlorobenzene	8.94
1-chloro-2-fluorobenzene	9.155
1-chloro-3-fluorobenzene	9.21
1-bromo-4-fluorobenzene	8.99
o-fluorotoluene	8.915
m-fluorotoluene	8.915
p-fluorotoluene	8.785
o-chlorotoluene	8.83
m-chlorotoluene	8.83

001687

TABLE C-12 (Cont.)
IONIZATION POTENTIALS (IP) OF
SOME AROMATIC COMPOUNDS

<u>Molecule</u>	<u>IP (eV)</u>
p-chlorotoluene	8.70
o-bromotoluene	8.79
m-bromotoluene	8.81
p-bromotoluene	8.67
o-iodotoluene	8.62
m-iodotoluene	8.61
p-iodotoluene	8.50
benzotrifluoride	9.68
o-fluorophenol	8.66

001688

TABLE C-13

IONIZATION POTENTIALS (IP) OF
SOME MISCELLANEOUS MOLECULES

<u>Molecule</u>	<u>IP (eV)</u>
ethylene oxide	10.565
propylene oxide	10.22
p-dioxane	9.13
dimethoxymethane	10.00
diethoxymethane	9.70
1,1-dimethoxyethane	9.65
propiolactone	9.70
methyl disulfide	8.46
ethyl disulfide	8.27
diethyl sulfite	9.68
thiolacetic acid	10.00
acetyl chloride	11.02
acetyl bromide	10.55
cyclo-C ₆ H ₁₁ CF ₃	10.46
(n-C ₃ F ₇)(CH ₃)C=O	10.58
trichlorovinylsilane	10.79
(C ₂ F ₅) ₃ N	11.7
isoprene	9.08
phosgene	11.77

001689

APPENDIX D: RELATIVE SENSITIVITIES FOR VARIOUS
GASES (10.2 eV Lamp)

001690

RELATIVE SENSITIVITIES FOR VARIOUS GASES

(10.2 eV Lamp)

<u>Species</u>	<u>Photoionization Sensitivity*</u>
p-xylene	11.4
m-xylene	11.2
benzene	10.0 (reference standard)
toluene	10.0
diethyl sulfide	10.0
diethyl amine	9.9
styrene	9.7
trichloroethylene	8.9
carbon disulfide	7.1
isobutylene	7.0
acetone	6.3
tetrahydrofuran	6.0
methyl ethyl ketone	5.7
methyl isobutyl ketone	5.7
cyclohexanone	5.1
naptha (86% aromatics)	5.0
vinyl chloride	5.0
methyl isocyanate	4.5
iodine	4.5
methyl mercaptan	4.3
dimethyl sulfide	4.3
allyl alcohol	4.2

*Expressed in ppm (V/V)

001691

RELATIVE SENSITIVITIES FOR VARIOUS GASES
(10.2 eV Lamp)

<u>Species</u>	<u>Photoionization Sensitivity*</u>
propylene	4.0
mineral spirits	4.0
2,3-dichloropropene	4.0
cyclohexene	3.4
crotonaldehyde	3.1
acrolein	3.1
pyridine	3.0
hydrogen sulfide	2.8
ethylene dibromide	2.7
n-octane	2.5
acetaldehyde oxime	2.3
hexane	2.2
phosphine	2.0
heptane	1.7
allyl chloride (3-chloropropene)	1.5
ethylene oxide	1.0
acetic anhydride	1.0
α -pinene	0.7
dibromochloropropane	0.7
epichlorohydrin	0.7
nitric oxide	0.6
β -pinene	0.5

*Expressed in ppm (V/V)

001692

RELATIVE SENSITIVITIES FOR VARIOUS GASES

(10.2 eV Lamp)

<u>Species</u>	<u>Photoionization Sensitivity*</u>
citral	0.5
acetic acid	0.1
nitrogen dioxide	0.02
methane	0.0
acetylene	0.0
ethylene	0.0

*Expressed in ppm (V/V)

001693

001694

APPENDIX E: hNu TROUBLE SHOOTING
GUIDE

001695

APPENDIX E

hNu TROUBLE SHOOTING GUIDE

1. No meter response in any switch position (including BATT CHK)
 - A. Broken meter movement
 - (1) Tip instrument rapidly from side to side. Meter needle should move freely, and return to zero.
 - B. Electrical connection to meter is broken
 - (1) Check all wires leading to meter and clean the contacts of quick-disconnects.
 - C. Battery is completely dead
 - (1) Disconnect battery and check voltage with a volt-ohm meter.
 - D. Check 2 amp fuse
 - E. If none of the above solves the problem, consult the factory.
2. Meter responds in BATT CHK position, but reads zero or near zero for all others
 - A. Input transistor or amplifier has failed
 - (1) Rotate zero control; meter should deflect up/down as control is turned.
 - (2) Open probe. Both transistors should be fully seated in sockets.
 - B. Input signal connection broken in probe or readout
 - (1) Check input connector on printed circuit board. Should be firmly pressed down.
 - (2) Check components on back side of printed circuit board. All connections should be solid, and no wires should touch any other object.
 - (3) Check all wires in readout for solid connections.
3. Instrument responds correctly in BATT CHK, and STBY, but not in measuring mode.
 - A. Check to see that light source is on

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APPENDIX E (Cont.)

hNu TROUBLE SHOOTING GUIDE

4. Instrument responds correctly in all positions, but signal is lower than expected.
 - A. Check span setting for correct value.
 - B. Clean window of light source.
 - C. Double check preparation of standards.
 - D. Check for proper fan operation.
 - E. Rotate span setting. Response should change if span pot is working properly.
5. Instrument responds in all switch positions, but is noisy (erratic meter movement).
 - A. Open circuit in feedback circuit. Consult the factory.
 - B. Open circuit in cable shield or probe shield. Consult the factory.
6. Instrument response is slow and/or irreproducible.
 - A. Fan operating improperly.
 - B. Check calibration and operation.
7. Low battery indicator.
 - A. Indicator comes on if battery charge is low.
 - B. Indicator also comes on if ionization voltage is too high.

001697

APPENDIX F: SELECTED RETENTION TIMES

001698

SELECTED RETENTION TIMES

ORDER OF ELUTION FOR T-8 COLUMN AT 0°C

Compound	Time, Seconds
Pentane	13.5
Freon 113	16.2
Hexane	19.8
Vinylidene Chloride	21.6
Heptane	26.1
Ethanethiol	26.1
Trichloroethane 1,1,1	51.3
Halothane	57.6
Methylene Chloride	63.0
Methyl Acetate	79.2
Ethrane	81.9
Trichloroethylene	84.6
Tetrahydrofuran	97.2
Acetone	98.1
Vinyl Acetate	99.0
Benzene	102.6
Chloroform	107.1
Ethyl Acetate	126.0
Methyl acrylate	138.6
Methyl Alcohol	143.1
Tetrachloroethylene	152.1
Methyl Ethyl Ketone	179.1
Acrylonitrile	202.5
Ethylene Dichloride	225.0
Toluene	232.2
Methyl Methacrylate	247.5
Ethyl Acrylate	247.5
Acetonitrile	324.0
Propanol, N	340.2
Methyl Isobutyl Ketone	450.0
Ethyl Benzene	464.4
Trichloroethane 1,1,2	1000.0
Styrene	1000.0
Pyridine	1000.0
Pentanol	1000.0
Ethylene Dibromide	1000.0
Butyl Acrylate	1000.0

ORDER OF ELUTION FOR T-8 COLUMN AT 40°C

Compound	Time, Seconds
Pentane	11.7
Hexane	12.6
Freon 113	12.6
Vinylidene Chloride	14.1
Ethanethiol	14.4
Heptane	16.2
Halothane	18.9
Ethrane	18.9
Trichloroethane 1,1,1	21.6
Methylene Chloride	23.4
Methyl Acetate	23.4
Trichloroethylene	27.9
Acetone	27.9
Ethyl Acetate	28.8
Vinyl Acetate	29.7
Tetrahydrofuran	29.7
Chloroform	30.6
Benzene	32.4
Tetrachloroethylene	36.0
Methyl Ethyl Ketone	39.6
Methyl Acrylate	41.4
Methyl Alcohol	45.0
Toluene	48.6
Acrylonitrile	49.5
Ethylene Dichloride	50.4
Ethyl Acrylate	50.4
Methyl Methacrylate	54.9
Propanol, N	61.2
Methyl Isobutyl Ketone	69.3
Acetonitrile	69.3
Ethyl Benzene	87.3
Ethylene Dibromide	162.9
Butyl Acrylate	165.6
Trichloroethane 1,1,2	167.4
Styrene	208.8
Pentanol	216.0
Pyridine	1000.0

001699

SELECTED RETENTION TIMES (Cont)

ORDER OF ELUTION FOR B-8 COLUMN AT 0°C

Compound	Time, Seconds
Freon 113	15.3
Pentane	18.0
Ethanethiol	18.0
Vinylidene Chloride	19.8
Hexane	21.6
Methylene Chloride	26.1
Methyl Acetate	30.6
Acrylonitrile	31.5
Vinyl Acetate	32.4
Ethrane	36.0
Methyl Alcohol	36.9
Halothane	36.9
Acetonitrile	36.9
Acetone	36.9
Trichloroethane 1,1,1	40.5
Heptane	45.9
Methyl Acrylate	48.6
Ethyl Acetate	49.5
Benzene	49.5
Chloroform	51.3
Tetrahydrofuran	65.7
Ethylene Dichloride	66.6
Trichloroethylene	76.5
Methyl Ethyl Ketone	76.5
Ethyl Acrylate	95.4
Methyl Methacrylate	100.8
Toluene	133.2
Tetrachloroethylene	171.0
Propanol, N	182.7
Methyl Isobutyl Ketone	278.1
Trichloroethane 1,1,2	313.2
Ethylene Dibromide	320.4
Ethyl Benzene	369.9
Styrene	677.7
Pyridine	1000.0
Pentanol	1000.0
Butyl Acrylate	1000.0

ORDER OF ELUTION FOR B-8 COLUMN AT 40°C

Compound	Time, Seconds
Pentane	11.7
Vinylidene Chloride	12.6
Hexane	12.6
Freon 113	12.6
Ethrane	12.6
Ethanethiol	12.6
Methylene Chloride	14.4
Vinyl Acetate	15.3
Trichloroethane 1,1,1	15.3
Methyl Acetate	16.2
Halothane	17.1
Chloroform	17.1
Acetonitrile	17.1
Heptane	18.9
Ethyl Acetate	18.9
Acrylonitrile	18.9
Methyl Acrylate	19.8
Ethylene Dichloride	19.8
Acetone	19.8
Methyl Ethyl Ketone	21.6
Methyl Alcohol	21.6
Benzene	21.6
Tetrahydrofuran	22.5
Trichloroethylene	23.4
Ethyl Acrylate	26.1
Methyl Methacrylate	27.0
Toluene	37.8
Propanol, N	38.7
Methyl Isobutyl Ketone	39.6
Tetrachloroethylene	43.2
Trichloroethane 1,1,2	54.0
Ethylene Dibromide	59.4
Ethyl Benzene	67.5
Butyl Acrylate	108.0
Styrene	117.0
Pentanol	163.8
Pyridine	1000.0

001700

SELECTED RETENTION TIMES (Cont)

ORDER OF ELUTION FOR G-8 COLUMN AT 0°C

Compound	Time, Seconds
Methyl Alcohol	21.3
Ethanol	23.9
Vinylidene Chloride	25.2
Pentane	25.2
Ethane	25.7
Acetone	27.5
Methylene Chloride	30.1
Methyl Acetate	30.1
Freon 113	30.1
Acetonitrile	30.1
Acrylonitrile	31.0
Halothane	35.4
Vinyl Acetate	43.2
Methyl Ethyl Ketone	48.7
Propanol, N	49.5
Hexane	49.6
Chloroform	55.8
Methyl Acrylate	56.7
Ethyl Acetate	59.4
Tetrahydrofuran	64.8
Ethylene Dichloride	68.2
Trichloroethane 1,1,1	70.2
Benzene	78.8
Trichloroethylene	121.5
Ethyl Acrylate	124.9
Heptane	134.6
Methyl Methacrylate	141.7
Methyl Isobutyl Ketone	182.5
Trichloroethane 1,1,2	225.0
Toluene	241.2
Pyridine	254.7
Ethylene Dibromide	291.4
Pentanol	360.0
Tetrachloroethylene	367.2
Ethyl Benzene	571.4
Styrene	916.2
Butyl Acrylate	1000.0

ORDER OF ELUTION FOR G-8 COLUMN AT 40°C

Compound	Time, Seconds
Pentane	11.5
Ethane	12.4
Ethanol	12.4
Methyl Acetate	13.3
Acetone	13.3
Methylene Chloride	14.2
Methyl Alcohol	14.2
Halothane	14.2
Freon 113	14.2
Vinylidene Chloride	14.4
Acetonitrile	15.9
Vinyl Acetate	16.8
Acrylonitrile	16.8
Methyl Ethyl Ketone	18.6
Hexane	18.6
Ethyl Acetate	18.6
Chloroform	18.6
Propanol, N	19.8
Ethylene Dichloride	21.3
Methyl Acrylate	21.3
Tetrahydrofuran	22.5
Trichloroethane 1,1,1	23.0
Benzene	24.8
Ethyl Acrylate	25.7
Trichloroethylene	27.5
Heptane	30.1
Methyl Methacrylate	31.0
Methyl Isobutyl Ketone	37.2
Trichloroethane 1,1,2	41.6
Toluene	45.0
Methyl Acrylate	56.7
Ethylene Dibromide	56.7
Tetrachloroethylene	65.7
Pentanol	77.4
Pyridine	85.5
Ethyl Benzene	94.8
Styrene	118.8
Butyl Acrylate	124.0

001701

APPENDIX G: GLOSSARY OF TERMS

001702

GLOSSARY

- AC battery charger - a black rectangular box with two cords attached to it. One cord plugs into an AC outlet, while the other cord attaches to the instrument being recharged. The OVA charger has a charge on/off switch.
- Backflush valve - on the OVA; used to reverse the hydrogen flow through the column; injected samples then flow directly to the detector.
- B-column - One of the three types of columns made for the OVA. This column contains 3% Diisodecyl Phthalate on chromosorb WAW 60/80 mesh. This is a low polarity column.
- Battery check - instrument switch on both the OVA and the hNu that indicates the charge in the battery.
- Battery pack - located on the front of the OVA and on the back of the hNu; serves as the power source of the instrument.
- Carrier gas - used in the OVA to carry ambient air through the column and to the detector, or directly to the detector. H₂ is the gas.
- Charcoal filter - there are two that can be used on the OVA. One is permanently attached and is used whenever a chromatogram is run. The other may be screwed into the probe/readout assembly.
- Chromatogram - a finger print of a sample. Different peaks on a strip chart represent different volatile organic chemicals. A chromatogram is obtained after a syringe injection of headspace gas is made into the column through the T-adaptor.
- Column - a variable length nickel tube (usually 8", 12" or 24") that contains a certain packing (Type T, B, or G).
- Concentration range selector - This is on the OVA and hNu. The desired range can be set when monitoring the ambient air. The OVA and hNu both have three settings: 1 to 10, 1 to 100, and 1 to 1000 on the OVA; while the hNu has 0 to 20, 0 to 200, and 0 to 2000.
- DOT exemption - a letter of exemption of the OVA from the aircraft rules which do not allow flammable gas to be shipped. This exemption may allow the OVA to be shipped or carried full on passenger aircraft.
- Electronic zero - found on the hNu; it is used to adjust the zero electronically when the instrument is placed in the standby position with the probe attached.

Fan - in the hNu, it maintains a flow of sample gas through the ion chamber.

Flame arrestor - a gold colored metal screen that contains the flame of the flame ionization detector. It is located at the bottom of the OVA.

Flame ionization detector - a detector that uses a flame, fueled by hydrogen, to ionize individual contaminants as they emerge from the column. The ions are then attracted to an oppositely charged electrode, causing a current and finally an electric signal to the Strip Chart Recorder.

Flame-out alarm - audible alarm that is activated when the flame in the flame ionization detector goes out.

Gas select knob - found on the OVA, it provides a choice of setting where a certain gas can be used to calibrate the instrument.

G-column - one of the three types of columns made for the OVA. This column contains a 10% OV-101 on chromosorb W AW-DMCS treated 60/80 mesh.

Glow plug - located in the chamber that supports the flame for the flame ionization detector. It provides the ignition source for the flame.

Headspace sample - a VOA vial filled three quarters of the way with water or soil. The remaining quarter of the vial is airspace.

Hydrogen - a diatomic gas that serves as the carrier gas and fuel supply for the OVA.

Hydrogen fill hose - a hose with a pressure gauge, an adaptor to a type 1A hydrogen cylinder, and an adaptor to the refill valve on the OVA. It serves to refill the OVA with hydrogen from the type 1A cylinder.

H₂ refill valve - This valve is only turned on when there is an open path through the hydrogen fill line to the type 1A hydrogen cylinder.

H₂ supply pressure valve - in the open position this valve allows a measured flow of hydrogen through the column and on to the detector in the OVA.

H₂ tank valve - in the open position this allows the hydrogen from the OVA's cylinder to flow to the H₂ supply pressure valve.

Ignite button - when this is depressed the element in the glow plug glows red hot and causes ignition of the flame of the flame ionization detector.

Injection - this takes place when a syringe containing gas is introduced into the column through the septum contained in the T-adaptor, and depressed so as to enter its contents into the column.

Instrument switch - found on the OVA, this switch turns on the electronics for the OVA except for the pump and glow plug.

Ionization energy - energy needed to ionize gaseous molecules. This is usually expressed as ionization potential.

Isothermal column - a column that is wrapped around a hollow metal tube and then insulated with styrofoam. The purpose of this structure is to keep the column at a fixed temperature throughout the analysis.

Lamp - found in the probe of the hNu, it emits ultraviolet light (photons) into the ionization chamber.

Mercury - used in making standards for the OVA. A small amount is used to cover the septum when the standard is inverted for storage in order to prevent the solvent vapor from escaping.

Mylar bag - used to hold a gas mixture, which can be introduced into the OVA or hNu through an attached hose or syringe injection.

"Off-scale" - term used to describe the full scale deflection of the needle for a particular concentration on the OVA or hNu.

Packing - the inner contents of the chromatographic columns used for the OVA. The different packings are designated by letters: T, B, and G.

Parts per billion - 1 part of a chemical in 1 billion parts of air or water (by volume).

Parts per million - 1 part of a chemical in 1 million parts of air or water (by volume).

Photoionization - the absorption of ultraviolet light (a photon) by a molecule that leads to ionization. $RH + h\nu \rightarrow RH^+ + e^-$, where RH is a trace gas and $h\nu$ is a photon with an energy greater than or equal to ionization potential of RH.

Photon - a quantity of ultraviolet light

Porous filters - particle filters that are found in the probe fixtures and at the junction of the umbilical cord and the side pack assembly.

Primary calibration gas - for the OVA this gas is a methane/air mixture, and the gas select knob is set at 3.0; while the hNu uses a benzene/air mixture and the span setting is 9.8.

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Probe/Probe readout assembly (OVA) - attached to the end of the umbilical cord of the OVA, it contains the inlet of the air sampling line and a dial with a linear scale readout.

Probe (hNu) - attached at the end of the electrical cord that originates from the instrument panel of the hNu. The probe contains a lamp, ionization chamber and a fan to draw in sample gas to the ionization chamber.

Probe extender - both the OVA and hNu have one. It attaches to the end of the probe to shorten the distance one has to get to the source of interest.

Pump switch - found on the OVA, when in the on position it pumps in ambient air at a rate of 2 units.

Retention time - the total time required for a volatile chemical to emerge from the column into the detector from the moment of introduction into the column of the OVA.

Sample screening - Determining total volatile organic chemical content of ambient air or a headspace sample by injection into the T-adaptor of the OVA while the OVA is in the backflush mode.

Sample flow rate gauge - This gauge is used to monitor the intake of ambient air by the pump.

Sample inject valve - When this valve is in the "up" position ambient air is pumped directly to the detector and the instrument is in the survey mode. If depressed during the survey mode, the ambient air is re-directed through a charcoal filter before continuing to the detector.

Septum - This is a replaceable, circular, rubber disc with a ten millimeter diameter that fits into the septum adaptor.

Septum adaptor - This screws onto the T-adaptor and provides a guide for the syringe during injections.

Side Pack Assembly - This is the main unit of the OVA. It contains most of the operating controls and indicators, the electronic circuitry, detector chamber, hydrogen fuel supply and electrical power supply.

Standard - This is a known chemical that is in solution with distilled water and contained in a VOA vial in such a way that a headspace is present. A syringe can then withdraw some of the headspace gas after the vial is agitated, and this gas can then be injected into the column for chromatographic analysis. Comparison to unknown samples then follows.

Standby knob - this is found on the hNu and allows the hNu to warm up in a non-emergency demanding position. The instrument can also be electronically zeroed at this position.

Strip Chart Recorder - a ticking type recorder that forms a permanent record of the electronic signals that come from the detector.

Survey mode - the OVA is in this mode when the sample inject valve is in the up position. In this mode ambient air is pumped directly to the detector.

Syringe - a gas tight hollow glass tube with a hollow needle on one end and a plunger on the other end that is used to collect headspace gas or ambient air for injections into the OVA.

T-Column - one of the three types of columns made for the OVA. This column contains a 1% 1,2,3 Tris (2 cyanoethoxy) propane (also known as TCEP) on chromosorb W HP, 60/80 mesh.

Teflon tape - used to obtain an air tight seal between connectors in the hydrogen line of the OVA.

Total volatile organic reading - measurement of total volatile organic chemical content of ambient air.

Ultraviolet light - This light or radiation has a wavelength (λ) between 4000-2000 Å.

Umbilical cord - two cords intertwined bridging the side pack assembly of the OVA to the probe assembly. This umbilical cord contains an electronic cable and an ambient air sampling line.

UV transmitting window - window on the UV lamp of the hNu that emits photons of UV light.

VOA Vial - a tubular glass vial with a rubber septum cap that is coated with Teflon on one side (usually 40 to 45 ml).

Volatile organics - organic chemicals that have low boiling points and high vapor pressures.

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APPENDIX V

LEVEL C DECONTAMINATION

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This Appendix contains decontamination procedures to be followed
in the event that Level C protection is required.

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ANNEX 3

LEVEL C DECONTAMINATION

A. EQUIPMENT WORN

The full decontamination procedure outlined is for workers wearing Level C protection (with taped joints between gloves, boots, and suit) consisting of:

- One-piece, hooded, chemical-resistant splash suit.
- Canister equipped, full-face mask.
- Hard hat.
- Chemical-resistant, steel toe and shank boots.
- Boot covers.
- Inner and outer gloves.

B. PROCEDURE FOR FULL DECONTAMINATION

Station 1: Segregated Equipment Drop

Deposit equipment used on-site (tools, sampling devices and containers, monitoring instruments, radios, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross-contamination.

Equipment: various size containers
plastic liners
plastic drop cloths

Station 2: Boot Cover and Glove Wash

Scrub outer boot covers and gloves with decon solution or detergent/water.

Equipment: container (20-30 gallons)
decon solution
or
detergent water
2-3 long-handle, soft-bristle scrub brushes

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Station 3: Boot Cover and Glove Rinse

Rinse off decon solution from Station 2 using copious amounts of water. Repeat as many times as necessary.

Equipment: container (30-50 gallons)
or
high-pressure spray unit
water
2-3 long-handle, soft bristle scrub brushes

Station 4: Tape Removal

Remove tape around boots and gloves and deposit in container with plastic liner.

Equipment: container (20-30 gallons)
plastic liners

Station 5: Boot Cover Removal

Remove boot covers and deposit in container with plastic liner.

Equipment: container (30-50 gallons)
plastic liners
bench or stool

Station 6: Outer Glove Removal

Remove outer gloves and deposit in container with plastic liner.

Equipment: container (20-30 gallons)
plastic liners

Station 7: Suit/Safety Boot Wash

Thoroughly wash splash suit and safety boots. Scrub with long-handle, soft-bristle scrub brush and copious amounts of decon solution or detergent/water. Repeat as many times as necessary.

Equipment: container (30-50 gallons)
decon solution
or
detergent/water
2-3 long-handle, soft-bristle scrub brushes

Station 8: Suit/Safety Boot Rinse

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Rinse off decon solution or detergent/water using copious amounts of water. Repeat as many times as necessary.

Equipment: container (30-50 gallons)
or
high-pressure spray unit
water
2-3 long-handle, soft-bristle scrub brushes

Station 9: Canister or Mask Change

If worker leaves Exclusion Zone to change canister (or mask), this is the last step in the decontamination procedure. Worker's canister is exchanged, new outer gloves and boots covers donned, and joints taped. Worker returns to duty.

Equipment: canister (or mask)
tape
boot covers
gloves

Station 10: Safety Boot Removal

Remove safety boots and deposit in container with plastic liner.

Equipment: container (30-50 gallons)
plastic liners
bench or stool
boot jack

Station 11: Splash Suit Removal

With assistance of helper, remove splash suit. Deposit in container with plastic liner.

Equipment: container (30-50 gallons)
bench or stool
liner

Station 12: Inner Glove Wash

Wash inner gloves with decon solution or detergent/water that will not harm skin. Repeat as many times as necessary.

Equipment: decon solution
or
detergent/water
basin or bucket

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Station 13: Inner Glove Rinse

Rinse inner gloves with water. Repeat as many times as necessary.

Equipment: water
basin or bucket
small table

Station 14: Facepiece Removal

Remove facepiece. Avoid touching face with gloves. Deposit facepiece in container with plastic liner.

Equipment: container (30-50 gallons)
plastic liners

Station 15: Inner Glove Removal

Remove inner gloves and deposit in container with plastic liner.

Equipment: container (20-30 gallons)
plastic liners

Station 16: Inner Clothing Removal

Remove clothing soaked with perspiration. Place in container with plastic liner. Do not wear inner clothing off-site since there is a possibility small amounts of contaminants might have been transferred in removing splash suite.

Equipment: container (30-50 gallons)
plastic liners

Station 17: Field Wash

Shower if highly toxic, skin-corrosive or skin-absorbable materials are known or suspected to be present. Wash hands and face if shower is not available.

Equipment: water
soap
tables
wash basins/buckets
field showers

Station 18: Redress

Put on clean clothes. A dressing trailer is needed in inclement weather.

Equipment: tables
chairs
lockers
clothes

C. FULL DECONTAMINATION (SIT. 1) AND THREE MODIFICATIONS

S I T	STATION NUMBER																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	X							X	X	X								
4	X							X	X	X								

Situation 1: The individual entering the Contamination Reduction Corridor is observed to be grossly contaminated or extremely skin corrosive substances are known or suspected to be present.

Situation 2: Same as Situation 1 except individual needs new canister or mask and will return to Exclusion Zone.

Situation 3: Individual entering the CRC is expected to be minimally contaminated. Extremely skin-corrosive materials are not present. No outer gloves or boot covers are worn. Inner gloves are not contaminated.

Situation 4: Same as Situation 3 except individual needs new canister or mask and will return to Exclusion Zone.

